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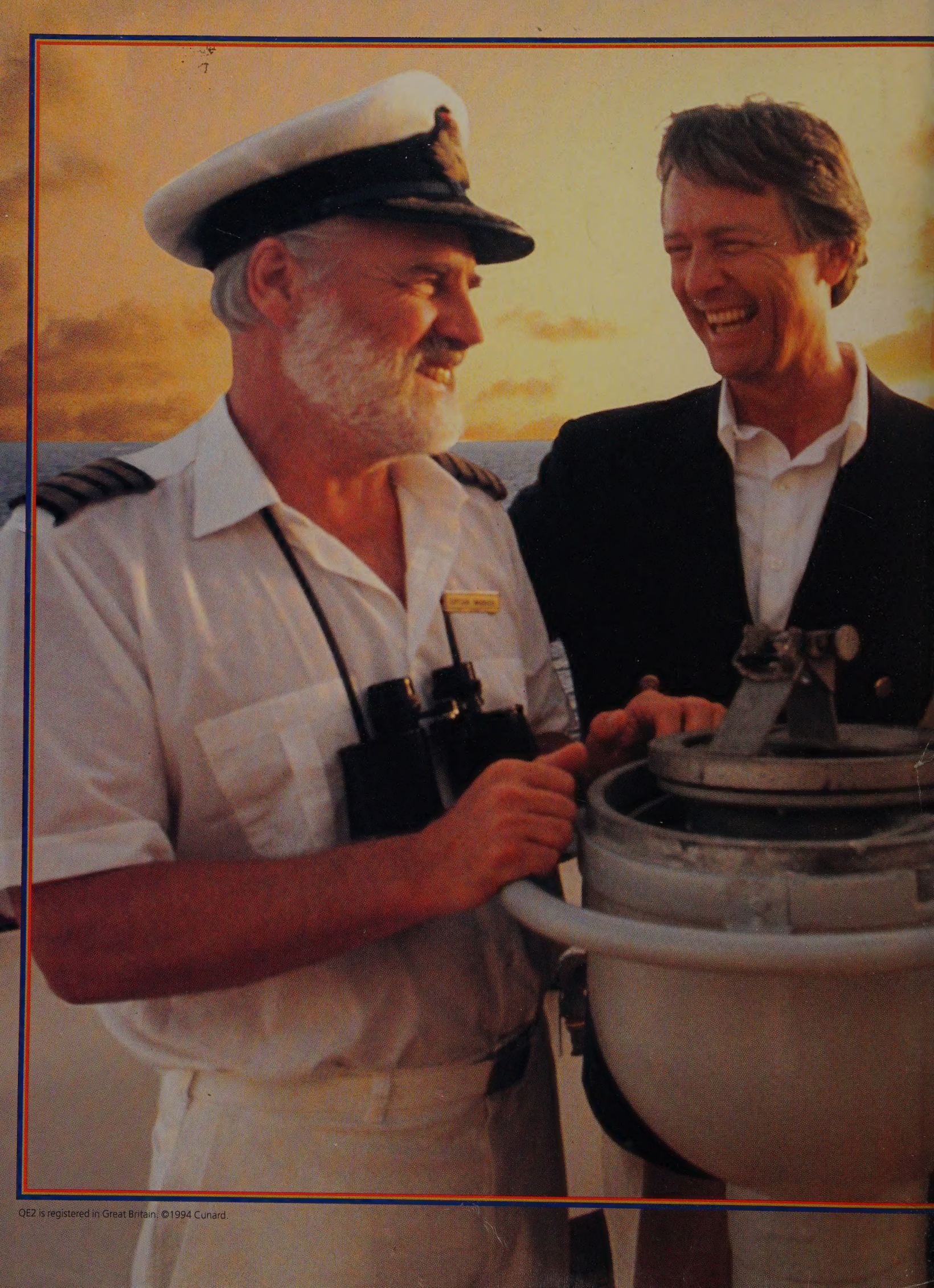

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UNIVERSAL'S FRANKENSTEIN

In "The Monster's Human Nature" ("This View of Life," July 1994), Stephen Jay Gould quite wrongly describes the portrayal of the monster in the 1931 film *Frankenstein*. Karloff's monster is, as Mary Shelley intended, "susceptible of love and sympathy." The monster's tragedy is the ignorance of those around him, not a "genetic" predisposition to evil. If Gould sees differently, that's understandable. The film's prologue, in which a "host" tells us that Frankenstein is creating evil, was intended to placate church and civic groups. Although the film soon contradicted its own stated theme, the dodge worked and apparently is still working sixty years later. Copernicus and Galileo on occasion tried similar diversions (which fooled no one) and are given points for cleverness. Let's give the same nod to Universal Studios, which at least succeeded in its subterfuge.

FRANK J. DELLO STRITTO
Bensalem, Pennsylvania

FIVE GIANTS

Edwin Colbert, in "Four Giants of Paleontology" (May 1994), omits any mention of Walter Granger, who was a key, but often unheralded, member of the Department of Vertebrate Paleontology during Henry Fairfield Osborn's reign at the American Museum.

Granger provided the department with an endless stream of mammal and dinosaur fossils, along with superb field notes—data that formed the basis of the research Colbert writes about.

Granger, with William Diller Matthew, worked to produce the famous Bridger Basin studies that led to Matthew's monograph on ancient carnivorous and insectivorous mammals. Their collaborative studies on the evolution of fossil horses and Lower Eocene mammals are paleontological classics. Granger also directed the posthumous completion of Matthew's San Juan Basin monograph, which Colbert cites as Matthew's "crowning work."

After his death in 1941, the American Museum eulogized Granger as "one of the great paleontologists...and a field collector [without] peer."

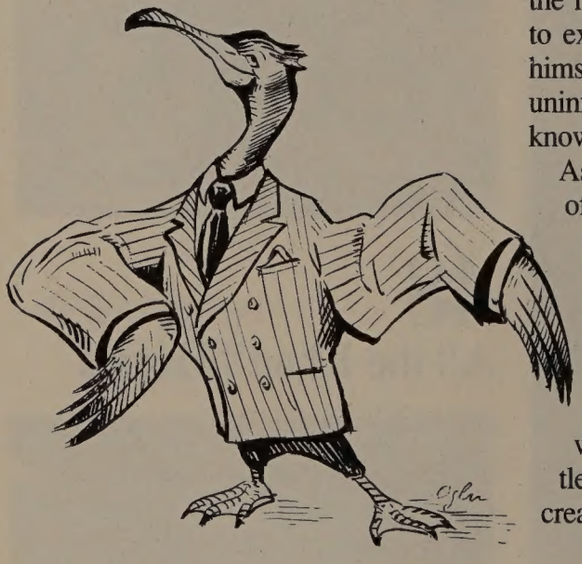
VINCENT L. MORGAN
KATHERINE R. MORGAN
The Granger Papers Project
Durham, New Hampshire

DOUBLE *What*?

We note with interest the mention of a new bird species, "the double-breasted cormorant," in Robert H. Mohlenbrock's "Bonaventure Island, Quebec" ("This Land," May 1994), but we were disappointed that it was not illustrated.

May we inquire whether it looks something like this?

WENDY SHADWELL, *Birder*
LAIRD OGDEN, *Artist*
New York, New York



The "double-crested cormorant" became "double-breasted" through an editorial error.—*Ed.*

GOD'S SCIENTISTS AND OTHERS

I very much appreciated Christopher Toumey's piece ("God's Own Scientists," July 1994) for its revealing but respectful view of a creation science discussion group and for his personal observations at the conclusion. I am both a Christian of Lutheran flavor and a scientist firmly convinced of evolution and teaching its mechanisms. I know I am one of many similarly inclined, faithful Christian lay people.

So much discourse on antievolution (including in your pages) runs roughshod over the very real needs of people to make an organic unit of their spiritual and physical lives. It is refreshing to find a kindred spirit in Toumey.

STUART A. SMITH
Ada, Ohio

Eugenie C. Scott, in "The Struggle for the Schools" (July 1994), mentions that evolved forms of the creationist argument continue to assault the courts of our land. Stephen Jay Gould, in his wonderful essay "Justice Scalia's Misunderstanding" (October 1987), pointed out that Justice Antonin Scalia, one of the dissenters from the 1987 Supreme Court decision striking down the Louisiana equal time act, holds the mistaken belief that evolution claims to explain the origin of life. Gould asks himself how Justice Scalia could "be so uninformed about the basic state of our knowledge?"

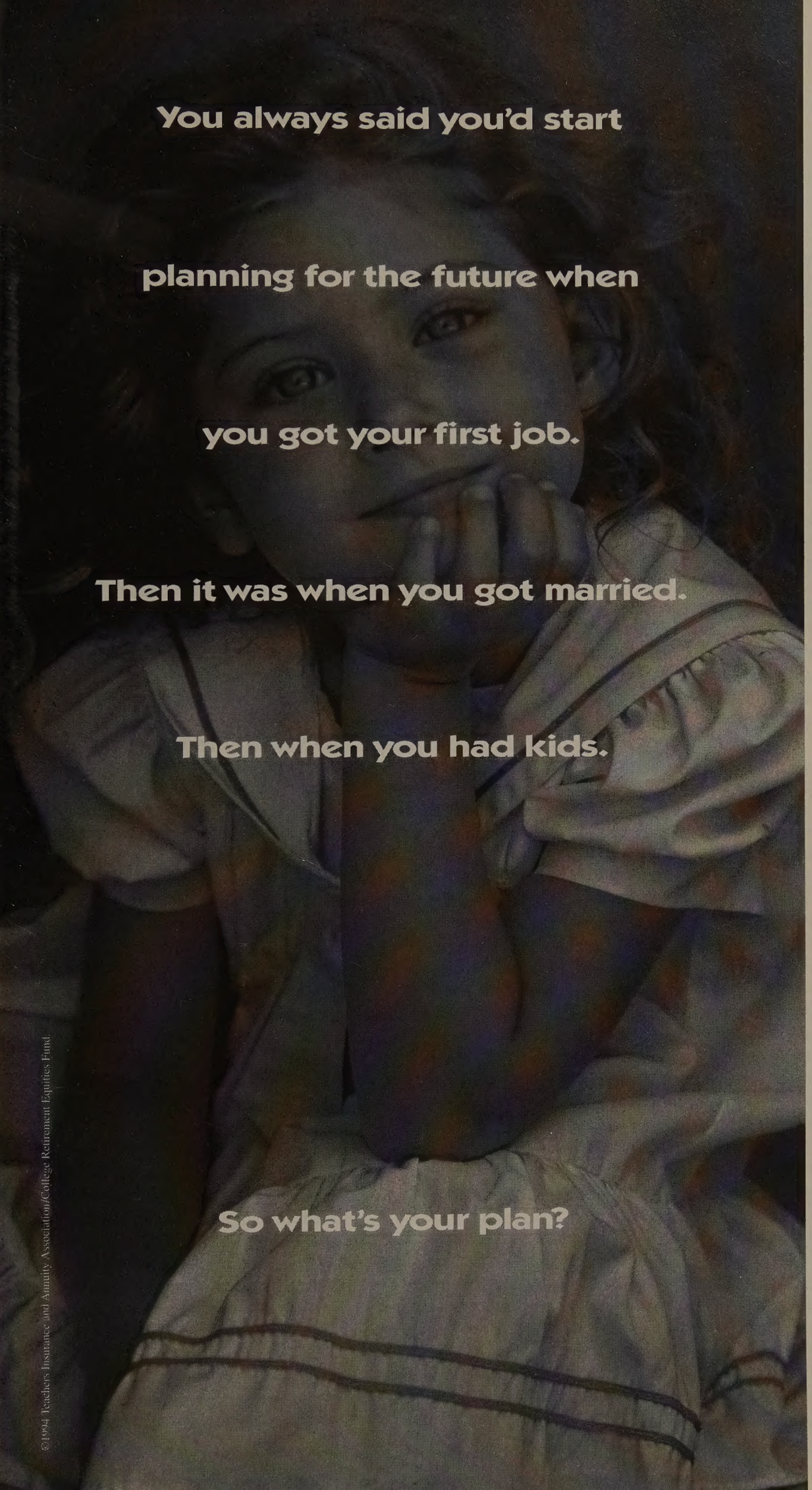
As scientists, we should do a better job of explaining that evolution is the study of how life changes *after* it originates. If a United States Supreme Court Justice doesn't understand evolution, then what chance does a public school teacher have of producing a generation of educated people who will not have to go to court to battle the next evolutionary stage of the creationist argument?

MATTHEW MACISAAC
Mahwah, New Jersey

GLANCING AT AN ECLIPSE

Stephen Jay Gould's August 1994 essay ("Happy Thoughts on a Sunny Day in New York City") was as delightful and thought provoking as we have come to expect, but I have an important cavil. It is dangerously untrue to say that we can "look directly at the sun for a moment without danger." Whether a "moment" is a minute or a few seconds doesn't matter; we will simply burn holes in our maculas.

EDWARD J. PRENNER, M.D.
Forest Hills, New York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Jove's Thunderbolts

Comet Shoemaker-Levy 9 was a pat on the back for science

by Stephen Jay Gould

One night in 1847, and partly to escape her parents' noisy dinner party, Maria Mitchell of Nantucket lugged her telescope to the roof of the Pacific National Bank (where her father worked as chief cashier) and discovered a comet five degrees from Polaris, the North Star. For this discovery, the first comet found by an American woman, Mitchell received many honors, including a gold medal from the king of Denmark and election, as the first woman ever so recognized, to the American Academy of Arts and Sciences in Boston.

(Mitchell's certificate of election still hangs on the wall of her birth house in Nantucket, and it is a painful and ambiguous thing to see. Two statements are crossed out: the printed salutation "Sir" has been altered to "Madam" by hand, and the designation of "fellow" has been replaced by "honorary member," meaning that Mitchell had not been granted voting privileges. The document is signed by Harvard's great professor of botany Asa Gray, later one of Darwin's stoutest supporters. More than ninety years would pass before another woman won election. Today, I am happy to report, for I am a member and the Academy's house lies just around the corner from my own, people of all shapes, sexes, colors, and backgrounds cavort in one of the oldest intellectual societies of our land with liberty and justice for all.)

A few other women excelled in astronomy during this age of nearly total exclusion for one sex from science, but most, like Caroline Herschel, gained access as sisters, wives, or daughters of male astronomers. Maria Mitchell, however, succeeded on her own. Her father, William, was an amateur astronomer, and he did rate ship's chronometers for part of his living (a vital activity in the great whaling port of Nantucket at a time when ships measured longitude by maintaining extremely accurate clocks on board). But William Mitchell was not a professional scientist, and he worked primarily as head cashier of a bank when Maria discovered her comet.

Maria Mitchell, who earned no college degree for want of opportunity, became the first female professor of astronomy in America, serving from 1865 to 1888 at Vassar College, where she vigorously promoted scientific education at America's premier college for women. She received honorary doctorates from Columbia, Hanover, and Rutgers. Maria Mitchell died in 1889. In 1902, family members and former students established the Maria Mitchell Association in Nantucket, an organization dedicated to astronomical observation and science education.

I gave the annual address at the Maria Mitchell Association on July 21, 1994. In lieu of an honorarium, I made one strong request: after my evening talk, I wanted to see Jupiter through Maria Mitchell's own telescope (not the original instrument of her 1847 discovery, for this machine resides in the Association's museum, but through the still-functioning five-inch refractor made by Alvin Clark of Boston and given to Mitchell in 1857 by an organization called the Women of America).

Call me foolish if you wish, but a professional lifetime as a paleontologist and evolutionist has led me to view connectivity and return to original sources as imbued with the highest value, both intellectual *and* ethical (or aesthetic). I wanted to see Jupiter that night through Maria Mitchell's telescope because she had been the great American pioneer in cometary discovery, and Jupiter, at that very moment, was being bombarded by a succession of more than twenty fragments from Comet Shoemaker-Levy 9. I was unable, I must confess, to make out the scars on Jupiter's surface through Maria Mitchell's telescope, for Jupiter had already set behind a clump of trees. But I waited patiently and finally saw the flicker of Jupiter among the leaves. Mission accomplished. Meanwhile, all the astronomical enthusiasts of Nantucket crowded around the adjacent computer, watching the latest information about Shoemaker-Levy 9 coming in on Internet from all over the world.

In March 1993, my friend and colleague Gene Shoemaker (world's expert on the geology of impact structures), along with Carolyn Shoemaker and David Levy, discovered a linear array of about twenty cometary fragments stretched out in a trail nearly 125,000 miles long near Jupiter. They determined that Jupiter's gravity had pulled the entire comet apart when it had passed within 60,000 miles of the giant planet's surface. They also recognized—and now the excitement started—that all these fragments would inevitably crash into Jupiter in July 1994.

What a show, and what timing—precisely at the twenty-fifth anniversary of Neil Armstrong's first step upon the lunar surface. But an epidemic of cold feet then gripped the astronomical community, and the spin doctors of diminished expectation raised their voices high. The impact would yield results of great scientific value to be sure, they said, but viewers shouldn't expect to see much of any visceral interest. The fragments would probably be pulled farther apart and burn into nothingness in the high reaches of Jupiter's atmosphere. Or, given our ignorance of cometary composition, perhaps the fragments contained little more than dust and ice—not the right

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* False. The *Dimetrodon* was actually an early relative of mammals that lived in North America some 280 million years ago.

MEMBERS CHOICE

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stuff to punch holes in a planet's surface. One commentator predicted impact flashes so small and fast that each would appear in no more than a single camera pixel from the *Galileo* spacecraft, poised near Jupiter. The semiofficial report in the July 14 issue of *Nature,* just a week before impact, went forth under the headline: "Comet Shoemaker-Levy 9: The Big Fizzle Is Coming."

I certainly understand the reasons for toning down expectations. The general ethos of science tends toward caution, especially before the fact—and astronomers had been badly burned twice in recent years, both times by comets, as Halley and Kohoutek truly fizzled relative to most people's expectations. In addition, scientists are still reluctant to grant much of a role to catastrophic agents as major players in the recent history of the solar system, and particularly the earth and its life. A whimper from Shoemaker-Levy 9, rather than a bang, would surely reinforce this old prejudice.

All the world now knows that Shoemaker-Levy 9 put on the show of shows, vastly exceeding all publicly expressed expectations, both in stunning visual terms and in a plethora of scientific data that will keep us busy for years to come. I am writing this essay on the weekend after the bombardment and cannot begin to make any sensible assessment of causes and reasons, but we need no more than a quick review of phenomena to illustrate the difference between a rave and a fizzle.

All twenty-one fragments of Shoemaker-Levy 9 hit Jupiter along a single latitude of the southern hemisphere. Impacts occurred during the Jovian night and were not directly visible from the earth. But Jupiter rotates in about nine hours, rather than our twenty-four, and the sites of impact moved quickly into our view, forming a chain of circular scars, some larger than the entire earth! We do not know how long the scars will last, or even whether their darkness records shadow or substance (blackened carbon or some forms of sulfur, have been suggested). We do not know how far the fragments penetrated Jupiter, or even what penetration means on a gaseous planet that has no discrete rocky surface—but white-hot gasses, presumably from the planet's interior, erupted through holes of impact "in great fireballs as if from cosmic cannons" (to quote Malcolm W. Browne, the *New York Times,* July 26).

The largest chunk of comet, called Fragment G, hit Jupiter at 3:30 A.M. on July 18, producing a flash and fireball that briefly exceeded the entire planet in brightness (so much for single pixels!). Fragment G may have plunged nearly forty miles into Jupiter's atmosphere. A plume of superheated gas then erupted and rose to a height of 1,300 miles above the impact site, yielding some of the most spectacular pictures of the entire week.

I have read various estimates of the size and power of this largest strike, but taking the most conservative figure reported in major scientific journals and newspapers (*USA Today,* July 22), Fragment G measured some 2.0 to 2.5 miles in diameter and hit with an explosive energy of about 6 million megatons of TNT. Taken all together, the twenty-one fragments, by this same estimate, released an equivalent of about 40 million megatons of TNT—or some 500 times the power of all the earth's nuclear weapons combined.

This comparison to the megatonnage of our entire nuclear arsenal sent shivers up my spine and brought forth from my memory a similar figure, which recalled the key debate within paleontology during the past decade, and also crystallized the various themes for this essay. In 1979, Luis Alvarez and his collaborators first published their theory that a large extraterrestrial object, a comet or an asteroid some six miles in diameter, struck the earth at the end of the Cretaceous period 65 million years ago, thus triggering one of the five great mass extinctions of life's history—the latest and, parochially for us at least, the most important, as this event wiped out dinosaurs and gave mammals their opportunity.

I knew nothing about the physics of impact at the time, and I remember harboring some strong initial doubts about the efficacy of such an event. I did understand how a crashing body might be decidedly unpleasant for a *Tyrannosaurus* caught di-

rectly in the path of descent, but why should an object only six miles across wreak such havoc upon a planet with a diameter of 8,000 miles? I expressed my naïve skepticism to Alvarez, a Nobel Prize-winning physicist who had worked on the Hiroshima bomb and certainly understood such matters, and he shut me up with the following estimate: a bolide six miles in diameter would strike the earth with 10,000 times the megatonnage of all the earth's nuclear weapons combined. Fragment G, in comparison, was a pipsqueak—yet this object tore an earth-sized hole in Jupiter and produced a fireball equal in brightness to the entire planet. If Fragment G could so impact giant Jupiter, shall we doubt the catastrophic effect of a much larger strike upon our much smaller planet?

When Alvarez and company first proposed their radical hypothesis of catastrophic extinction, paleontologists almost to a person rejected the idea with ridicule and vehemence. (Both for the decent purpose of allowing you to judge my argument more fairly, and for an utterly base motive of bragging in retrospect, I must confess my biases and place myself among the "almosts" as one of Alvarez's rare paleontological supporters from the start.) Since then, however, evidence for impact has accumulated to virtual proof—first the initial discovery of iridium at high concentration in strata marking the extinction (for iridium is almost absent in indigenous sediments of the earth, but present at normal cosmic abundances in comets and asteroids); then the finding of shocked quartz in the same sediments (for this unusual form of a common mineral can be generated, so far as we know, only by high pressures associated with impacts, and not by any internal process known to act at or near the earth's surface); and finally the apparent "smoking gun" itself, a massive crater of the right age, and up to 200 miles in diameter, off Mexico's Yucatán Peninsula.

In the light of such overwhelming support for impact, opponents of catastrophic extinction have generally retreated to the fallback position that a comet or asteroid did indeed strike our planet, but that the extinction had other earth-based and more gradualistic causes (granting, at most, the terminal and ineffective role of *coup de grâce* to the great explosion). This argument fails no logical test, but I would be mighty surprised if it succeeds. Coincidences do occur, but we should not seek their complexities as favored modes of explanation. Why argue that a bolide hit the earth just when a great extinction happened to be occurring for other, unknown reasons, when the bolide itself can do the work required?

When such strong hostility greets such an interesting theory, and continues with substantial vigor even after the theory has been effectively validated, we must seek deeper causes rooted in general philosophies and methodologies. No theoretical preference has been so strong and dominating in the earth sciences as Charles Lyell's doctrine of uniformitarianism—a complex set of ideas centered upon the notion that current and observable causes, acting at characteristically minute and gradual rates, can produce all the grand effects of the earth's history by accumulating their tiny increments through the immensity of geological time. To produce the Grand Canyon over time's vastness, erode the Colorado River valley grain by grain. To populate the earth with novel fauna, extirpate old species and evolve new forms one by one, so that any observer at a moment in time would notice nothing. At most, under the uniformitarian perspective, climates and topographies might occasionally alter at especially high rates, promoting more species deaths than usual over a relatively short interval—but never a truly catastrophic mass extinction. Both Lyell and Darwin strenuously argued that so-called mass extinctions must spread out over several million years (with the appearance of suddenness arising as an artifact of an imperfect geological record) and that the causes of such episodes could only reside in an intensification of ordinary processes.

This issue of uniformitarian versus catastrophic change stands as one of the grand questions of science, for the debate pervades so many disciplines and bears so strongly upon some of the most profound puzzles of our lives. Consider just two of the deep issues. *The nature of change itself:* Is human culture, life, the physical universe indefinitely mutable and subject to continuous and usually insensible change (the uniformitarian view), or does stable structure characterize most forms and institutions, with change therefore concentrated in rare and rapid episodes of transition between stable states, often initiated by catastrophic disturbances to which existing systems cannot adjust? *The nature of causality:* Do large effects arise as simple extensions of small changes produced by the ordinary, deterministic causes that we can study every day, or do occasional catastrophes introduce strong elements of capriciousness and unpredictability to the pathways of planetary history?

William Glen, a distinguished geologist and historian of science at the United States Geological Survey in Menlo Park, California, has spent the last fifteen years working in the interesting area of scientific revolutions in the making. He first wrote a fine book on what most people have judged as the greatest revolution in geology since the discovery of time's vastness in the late eighteenth and early nineteenth century: the development of the theory of plate tectonics and the consequent validation of continental drift (*The Road to Jaramillo,* Stanford University Press, 1982). During the past decade, Glen has been tracing the movement of Alvarez's asteroid from heresy to orthodoxy, and chronicling the regrowth of catastrophist thinking in general, particularly in the context of discussion about mass extinction (see his recent book *The Mass Extinction Debates: How Science Works in a Crisis,* Stanford University Press, 1994).

Glen surprised the hell out of me one day by saying that he regarded the debate over catastrophic mass extinction as potentially more important in the history of science than plate tectonics. Much as I might like to accept such an argument, I initially cringed and strongly objected, for I had so long accepted the virtual mantra among geologists that no reformulation could be more profound than plate tectonics—the earth's surface broken into thin plates in motion, with new crust welling up at oceanic ridges, spreading out to form and push the plates and eventually descending back into the earth at subduction zones.

But Glen reminded me of the famous statement by Freud that I have often quoted in these essays: the most important scientific revolutions have, as their only common feature, the dethronement of human arrogance from one pedestal after another of previous convictions about our own cosmic importance. At the very least, great revolutions must alter some central concept about our lives or the workings of the universe. Plate tectonics radically changed the physics of the earth, but few fundamental tenets of human life or physical causality were altered thereby. We believed, before, that the earth's crust could move up and down to form mountains and ocean basins; we know, after, that planetary real estate flows laterally as well.

But catastrophic impact theory, as Bill

Glen argued with great force, has much broader implications if it can be established as a generality in the mechanisms of planetary history, and not just as an explanation for a few peculiar events, including the Cretaceous–Tertiary extinction. For if impacts shape much that matters in geological time, then catastrophism becomes at least coequal with a previously dominant or nearly exclusive uniformitarianism—and all our views on the nature of change and causality must be revised. Moreover, these potential revisions speak to the tensions that Freud identified as both scary and liberating—for catastrophism supports themes that many of us would rather not acknowledge about chance and unpredictability in the evolution of all lineages, including our own. No random bolt from the blue 65.3 million years ago, no extinction of dinosaurs, no mammalian dominance, no human life today—whereas the uniformitarian perspective harmonizes much better with traditional ideas of a gradual rise to inevitable success by mammals.

As a believer in connectivity with initial sources, as illustrated earlier by my tale of Maria Mitchell's telescope, I decided then to excavate the original definition of geology's great dichotomy in an attempt to understand the importance of catastrophism's resurgence and the role of Shoemaker-Levy 9 as a contribution to the argument. The terms "uniformitarian" and "catastrophist" were coined by William Whewell, England's leading philosopher of science, in a review of the second volume of Lyell's *Principles of Geology* (published in the *Quarterly Review,* vol. 47, for March and July, 1832). Whewell wrote:

> Have the changes which lead us from one geological state to another been, on a long average, uniform in their intensity, or have they consisted of epochs of paroxysmal and catastrophic action, interposed between periods of comparative tranquility. These two opinions will probably for some time divide the geological world into two sects, which may perhaps be designated as the *Uniformitarians* and the *Catastrophists.*

G. P. Scrope, one of Lyell's leading geological colleagues, read Whewell's review and wrote to Lyell suggesting that the dichotomy might easily be resolved or compromised:

> As to the dispute he speaks of, which I know has now and then raged pretty warmly between you as a Uniformitarian and the Catastrophists I do not see any but an imaginary line of separation between you. It is only a dispute about degree, a plus or minus affair; a little concession on either side will unite you in perfect cordiality.

But Lyell firmly rejected this mediation and stuck by Whewell's division. He wrote to Whewell, quoting Scrope's opinion and then adding his own support for a dichotomy of principle:

> On this point I cannot budge an inch for reasons to be developed in v. 3 [that is, the third volume of his *Principles of Geology,* published the next year in 1833]. It is of course a question of probability to some extent in the present state of our knowledge, but I consider it a most important question of principle, whether we incline to the probabilities as seen in the last 3000 years or possibilities which I hold to be uncalled for by any overwhelming evidence.

In other words, Lyell writes, why invent unseen (and catastrophic) forces when slowly acting present causes, observed for more than 3,000 years, suffice to render all geological events in the fullness of time.

The intensity of Lyell's rhetorical support for uniformitarianism may best be judged in the famous first chapter of volume 3, composed in the light of Whewell's review and its codified dichotomy (later editions of the *Principles of Geology* dispersed the material of this short, seven-page chapter into earlier parts of the book). Catastrophism, Lyell argues, must be rejected as a speculative system that will degrade geology to a playground of untestable conjecture, whereas uniformitarianism, firmly grounded in observation of present causes, will establish geology as a rigorous, empirically based, mature science. Lyell was a lawyer by profession and a brilliant writer by avocation. No one has ever matched him for persuasive prose:

> Never was there a dogma more calculated to foster indolence, and to blunt the keen edge of curiosity, than this assumption of the discordance between the former and the existing causes of change. It produced a state of mind unfavorable in the highest conceivable degree to the candid reception of the evidence of those minute, but incessant mutations, which every part of the earth's surface is undergoing.... We hear of sudden and violent revolutions of the globe, of the instantaneous elevation of mountain chains, of paroxysms of volcanic energy.... We are also told of general catastrophes and a succession of deluges, of the alternation of periods of repose and disorder, of the refrigeration of the globe, of the sudden annihilation of whole races of animals and plants,

"I think this may explain the disappearing frog population."

Going Down the Drain

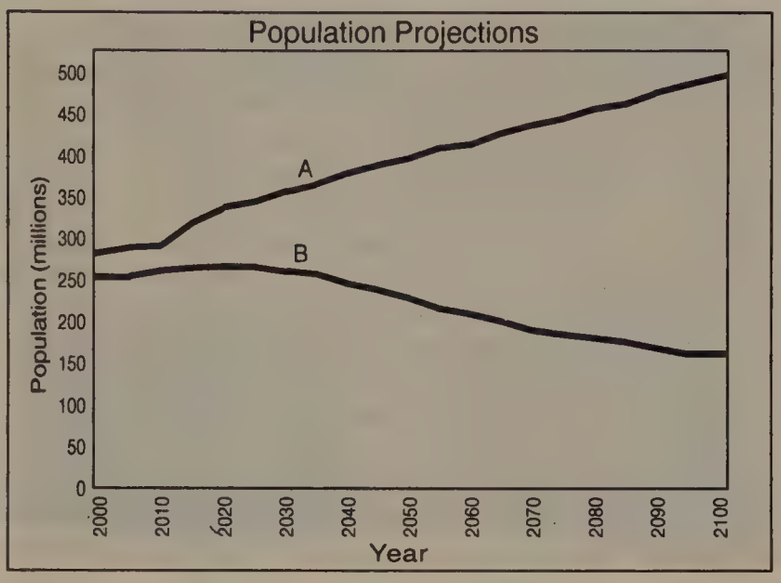
That headline may not be scholarly, and the tone is perhaps too flippant for a deadly serious matter. Still, it would be hard to find a more apt description of where our country is heading as a direct result of the relentless growth of our population.

The arguments for first halting, then reversing, U.S. population growth would seem so compelling as to raise the question "Why isn't it being done?".

Line A shows where our population is headed with current levels of fertility and immigration— to nearly 400 million by 2050, and to nearly a half billion by the end of the next century!

Such population growth would surely lead to disaster for future generations of Americans. It would have profound impacts upon the environment, on renewable resources like farmland, forests and water, and on our society itself.

A smaller population would help the nation deal with the social, environmental and resource problems that confront us, yet very few of our politicians and pundits even consider the idea.



On the assumption that they are held back by unwarranted fears, we will try to explain briefly by what relatively gentle adjustments we could turn U.S. population growth around.

Line B shows what could be achieved with the "two child family" and with immigration reduced to the levels that prevailed for much of this century.

If parents indeed "stop at two" it would lead to a total fertility rate (TFR) of about 1.5 children, because not all women have children, and some have only one. A national TFR of 1.5 would make possible a gradual turnaround in the population growth that drives our social and environmental problems.

We Need to Reduce Immigration

But the two child family alone will not enable the nation to reach a smaller population size. It would need to be accompanied by a substantial reduction in current levels of immigration.

In 1900 we were a nation of less than 76 million. Almost half of the population increase since then has been post-1900 immigrants and their descendants. The Census Bureau projects that our present population of some 260 million will increase by 2050 to 392 million (middle projection), or even to 522 million (high projection).

Of the population growth anticipated for the 21st century, nearly 90 percent will be post-2000 immigrants and their descendants. In other words, immigration is the driving force behind a disastrous surge of population growth.

The average annual level of recorded gross immigration from 1924 through the 1960s was 198,000. Immigration is now over a million per year. If we were willing to bring net immigration down to 200,000 a year, our demographic future would improve dramatically.

If we moved now to the "two child family" and concurrently brought immigration under control at an annual level of 200,000, it would lead in the next century to the population projection shown in the graph *(Line B)*.

By the middle of the next century parents could even be encouraged to have more children, for a total fertility rate of 1.9. That rate would allow our nation to maintain a constant population size of around 150 million.

If, at the same time, we change our lifestyles to reduce unnecessary consumption, and use energy and materials far more efficiently, such a population size should be sustainable for the very long term.

The Choice Is Ours

We need to choose the path leading to a sustainable U.S. population of around 150 million. To get there we would need the combination of the two child family and a moderate net immigration of 200,000 a year. What would be so difficult about that?

We need, above all, the courage to make now the decisions that would safeguard our demographic future. We urge Third World nations to bite the bullet and face up to their demographic problems. How about doing it ourselves?

NPG has recently published a paper titled, The Two Child Family, documenting the case made here. To become a member, and receive our papers on a regular basis, please send us your check today.

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and other hypotheses, in which we see the ancient spirit of speculation revived, and a desire manifested to cut, rather than patiently to untie, the Gordian knot.

I have long regarded Lyell's argument as deeply unfair in principle, however brilliant in rhetoric—yet he prevailed for nearly 150 years, thus restricting the range of geological hypotheses. He argues that we should prefer direct observation to any form of inference (labeled as "speculation" in his rhetoric). Catastrophism then loses by unjustly blinkered definition, rather than by fair test. If the catastrophic model has any validity, then natural forces of paroxysmal intensity occasionally impact the globe to great and sudden geological effect, but at very infrequent intervals. If the waiting time between such events usually amounts to millions of years—as must be the case for large impacts producing global mass extinctions—and if human observation of present processes has been limited to only a few thousand years, what chance do we have of ever observing such catastrophes over the course of human history?

We cannot reject plausible forces because we do not see them directly. Most of science relies upon ingenious and rigorous inference, not passive observation alone. We were quite confident about many phenomena—atoms and black holes among them—before we developed technologies for their visualization. How can we ridicule a force that we have not seen for 3,000 years, when good theory predicts that its momentary episodes of operation should be separated by many millions of years? Why are we so loath to accept global catastrophes as major actors in the history of the earth and life when we have seen the commoner events of smaller scale that occur so much more frequently? The Tunguska object, the cometary fragment that exploded 28,000 feet above Siberia in 1908, flattened a thousand square miles of forest and would have produced the greatest disaster in human history had it struck anywhere near a population center. The Tunguska object, by best estimate, measured about 300 feet in diameter. Such small particles hit the earth with waiting times of hundreds to thousands of years and can therefore be studied as rare historical events. May we not extrapolate from these to the much rarer giant bolides, with diameters measured in miles, that must strike the earth with waiting times of tens to hundreds of millions of years, but with massive global effects and with sufficient frequency to shape much of planetary history in a half dozen or so good strikes during the tenure of multicellular animal life?

Lyell had lobbied hard to secure Whewell's review in the most prestigious of British journals. But Whewell, while praising the book and fairly describing Lyell's system, then argued that Lyell had been unduly restrictive in his uniformitarian rigidity and that the case for catastrophism remained open in principle. In other words, the issue must be settled by scientific study (observation *and* inference), not by a priori definition. Whewell wrote in defense of catastrophism, and in the next paragraph following his definitions:

> It seems to us somewhat rash to suppose, as the uniformitarian does, that the information which we at present possess concerning the course of physical occurrences, affecting the earth and its inhabitants, is sufficient to enable us to construct classifications, which shall include all that is past under the categories of the present. Limited as our knowledge is in time, in space, in kind, it would be very wonderful if it should have suggested to us all the laws and causes by which the natural history of the globe, viewed on the largest scale, is influenced—it would be strange, if it should not even have left us ignorant of some of the most important of the agents which, since the beginning of time, have been in action; of something, in short, which may manifest itself in great and distant catastrophes.

We didn't need Shoemaker-Levy 9 to validate catastrophism by the most direct route of overt observation. We were fortunate indeed to witness any event at such a scale during the few hundred years that technology and enlightened understanding have combined to give us tools of comprehension. The Cretaceous bolide had pretty much proved itself through inferences based upon fossilized results a few years before Jupiter fractured Shoemaker-Levy 9 into its twenty-one murderous bits.

Shoemaker-Levy 9 must therefore represent an indulgence of nature—a gift to us, a reward for our proper use of scientific inference to validate at least one global catastrophe (the terminal Cretaceous bolide) against all the prejudices of our uniformitarian training. Nature almost seemed to be saying to her wayward and insignificant child on earth: "You did it the right and hard way, by difficult inference; well done, thou good and faithful servant; now I will show you a cosmic catastrophe directly, and for free, even though such an event might plausibly not occur for many thousands of years."

All this, of course, is metaphor. I have not become an addlepated New Ager, and I do not believe that nature operates by anything akin to our notion of intent. We just caught a break with Shoemaker-Levy 9. But do consider two more truly wondrous events in closing. Shoemaker-Levy 9 hit Jupiter precisely to the day of the twenty-fifth anniversary of our first human landing on the moon. Is nature returning the compliment of our respectful foray into her realm by teaching us something fundamental about her ways at such an auspicious moment? Let us also, and finally, thank nature for setting this display on a distant and giant planet that can easily bear the shock, and not closer to home where a similar event might relegate us to the fate of the dinosaurs.

"I understand there's a newt in the House of Representatives."

Stephen Jay Gould teaches biology, geology, and the history of science at Harvard University.

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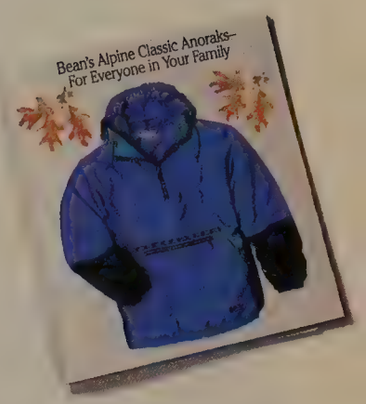
L.L.Change of Season

L.L.Places to Go

L.L.On the Road



L.L.Down East

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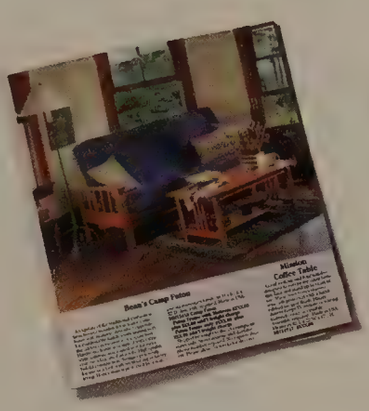

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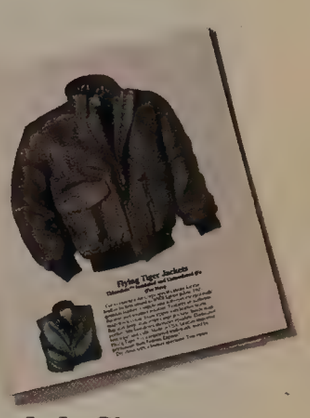

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Adiós, Locos?

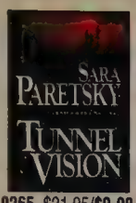
An ancient mollusk is disappearing—and not at a snail's pace

by Louis H. DiSalvo

Along the 3,000-mile coastline from mid-Peru to southern Chile lives a gray marine snail, with a flattened, bowl-shaped shell about as big as your hand. It lives on rocks that may be just below the water's surface or as much as ninety feet down. Known to science as *Concholepas concholepas,* the snail is commonly referred to, for obscure reasons, as the "loco." Humans are the loco snail's only serious predator; they wade, swim, and dive in hordes to capture every visible specimen. In 1980, loco divers were selling more than 26,000 tons of these mollusks annually. During the past decade, however, the catch has dwindled to a small fraction of its former tonnage. As the snail becomes rarer, the value of its meat keeps rising. Now snail hunters will risk arrest and even the disappearance of the species in their quest to satisfy the market's demands.

I first saw a loco a little more than a dozen years ago when I first arrived in Chile. It was on a plate in a restaurant in Santiago; nearby on the table sat a loco-shell ashtray. Since a moratorium on collecting them was imposed in 1985, locos are not listed on restaurant menus. However, if you whisper to the waiter, you can probably get two illegally obtained, undersized prizes on a bed of lettuce with mayonnaise ("locos mayo") for about ten American dollars. Illegal trade is brisk. In late 1991, a clandestine packing operation was raided near Santiago and more than 70,000 locos were seized. When the ban on taking these snails was lifted for fifteen days in 1988, several fishing ports in southern Chile experienced a brief "gold rush." Loco divers and their boatmen made and lost fortunes in a few days. Some had sailed more than a thousand miles to the last richly productive loco grounds. During those two weeks, more than 12,000 tons of locos were exported.

Tons of discarded loco snail shells litter the shores of a coastal bay in Valdivia, Chile. Despite the mollusk's protected status, poaching remains common.
Ricardo Carrasco-Stuparich



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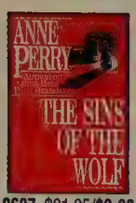

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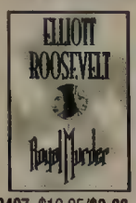

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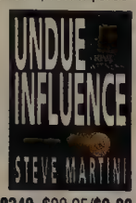

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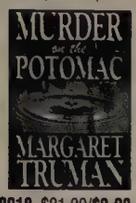

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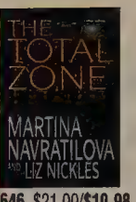

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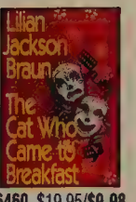

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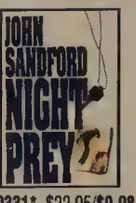

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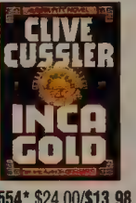

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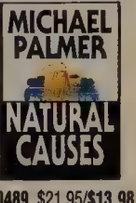

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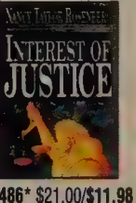

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Apparently, divers had been at work for months establishing underwater stockpiles in anticipation of opening day.

Locos constituted the world's largest gastropod fishery in the early 1980s, when they were being exported as "Chilean abalonelike shellfish" to Asian markets. This label arose only from commercial necessity; locos may taste somewhat like abalone, but the resemblance is superficial. Although both are flat-shelled gastropods, abalone shells have perforations and pearlescent colors that locos do not. The loco's shell is drab inside and out and is usually covered with barnacles.

A much older evolutionary group, abalones have diverged into numerous species around the world, while the genus *Concholepas* has only one living species, the loco, which lives only on the South American temperate west coast. Nor do locos behave like abalones. The latter are tranquil grazers on marine algae, whereas locos are persistent carnivores that attack barnacles, several species of mussels, and tunicates (sea squirts). Years ago, I found that locos would even attack and consume California abalones, which were being tested for introduction to Chile. Predation by locos is one possible explanation for the inability of abalones to colonize temperate South American waters.

The loco thrives in nutrient-rich local waters, where phytoplankton proliferate. Barnacles, mussels, and tunicates thrive on these microscopic plants and are in turn consumed by the locos. When unmolested, the locos become populous. Older fishermen remember when they were plentiful everywhere, but today large numbers can be observed only in specially protected research reserves.

Abalone larvae hatch from yolk-filled eggs; they settle to the bottom of the sea in a few days and begin to feed. In contrast, locos reproduce by depositing hundreds of white, inch-long capsules on subtidal rocks; each capsule contains thousands of fertilized eggs, which develop into tiny shelled larvae, or veligers. After about one or two months' incubation in the capsule, the veligers are released into the ocean where they swim about freely, using their swimming organ (velum), which also serves as an efficient device for trapping phytoplanktonic food. A few months after the larvae have left the capsules, miniature locos begin to appear on wave-swept rocks. Although Juan Carlos Castilla, of the Catholic University in Santiago, and his associates had described the later phases of the loco's natural history in nu-

merous papers published from 1976 to the present, little was known about the animal's free-swimming planktonic stage or its life as a tiny bottom feeder.

Widely dispersed in the plankton, maturing loco larvae seek surface waters, and are difficult to capture or study. They apparently move to varying depths as they react to light and food—which also makes them a difficult target for predators. Laboratory observations suggest that when the tiny larvae are getting ready to settle, they swim near the ocean floor, out of reach of plankton nets. Before my lab studies, no one could recognize loco veligers among the other molluscan larvae, since no one had cultured locos to obtain reference specimens. Two-millimeter-sized snails are not easily spotted on boulder-strewn shores carpeted with marine life and pounded by waves.

During the mid-1980s, I was able to culture locos in the laboratory for the first time and watch the larvae grow from three-tenths of a millimeter into ready-to-settle specimens nearly two millimeters in length. To raise them took about a hundred days of patiently changing water, feeding the larvae with microalgae, and treating them with antibiotics to prevent bacterial diseases from killing them. Out of half a million larvae, I was able to shepherd seven into settling, but only one grew into an adult loco.

Now I had reference specimens that allowed me to recognize the loco larvae in mixed plankton samples taken from the ocean. Also, I learned that the older, ready-to-settle larvae migrate to the sea surface, and are probably blown ashore by spring winds, as are other planktonic larvae of shore-dwelling invertebrates. From the top of their foot, advanced loco larvae produce a byssal thread that they use to suspend themselves from the water surface much as spiders hang from a ceiling. They can also abandon the thread and crawl upside down on the surface film, as do many freshwater snails. In strongly agitated water, where the swimming organ could be damaged or the byssal thread lost, larvae envelop an air bubble with their foot to keep from sinking. Such behavior may allow planktonic larvae to travel great distances and survive rigorous wave action. Although feeble swimmers, they need only move up or down to catch an ocean current or wind-driven surface slick that may carry them for hundreds of miles. Myriads have been lost at sea, leaving only the best evolved navigators to float to shore.

Based on my laboratory observations, I designed a net for collecting surface plankton and was surprised and pleased to find three ready-to-settle loco larvae among my first catch. Although the larvae were normally scarce (averaging only one for each half mile the net was towed), I soon had enough to observe their metamorphosis in the laboratory.

I set up some aquariums with naturally encrusted stones and a strong water current vigorously agitated with compressed air to simulate a wave-swept coastline. The larvae drifted around, trailing byssal thread "lassos," which soon caught on the rocks or even on actively bubbling air stones. When pulled to a rock by its elastic thread, a larva would adhere to the surface using the suckerlike extension of its foot, made sticky by mucus. Because their small size allows them to anchor within a clinging microlayer of water, they could then crawl around on the rock, unaffected by wave motions. If the rock surface was biochemically attractive for an extended stay, they would absorb the parachutelike velum in as little as two hours. When they found the surface noxious or uncomfortable, however, they extended the velum and were lifted away on the currents to seek a different settlement site. Many molluscan larvae are capable of delaying their

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Two eyes and a mouth are positioned near the center of a drifting loco larva, from which four armlike lobes radiate. Blown to shore by winds, loco larvae eventually settle on rocks.

An adult loco, its shell covered with barnacles, perches on an intertidal rock. Two white "teeth" on the shell's right edge are used to harvest rock-bound barnacles for food.

Photographs by Louis DiSalvo

metamorphosis until they have found an appropriate surface.

A few years ago, Daniel Morse, of the University of California at Santa Barbara, demonstrated the intricate biochemical interactions between abalone larvae and their settlement surfaces. Although the loco is not closely related to abalones, some of the same principles probably apply. Larvae of several invertebrate species are known to be attracted by chemical substances emitted by their own species or by prey. Following such chemical trails enhances their chances of finding food or mates.

Recently metamorphosed locos begin their postlarval lives scraping microalgae off the rocks, as do abalone. Later, however, they will become carnivores. Also, in contrast to abalone, which begin to enlarge their shells shortly after they settle and begin feeding, the locos pass through a further set of changes. During their algal feeding period, which lasts from one to several days, the young loco's shell changes from transparent to a deep chestnut brown. This pigmentation leaves the shell at least five times more resistant to breakage than it was during the loco's planktonic odyssey; this added strength enhances its chances of surviving the rough surf.

Once pigmented, the tiny locos become carnivorous, attacking prey with exquisite precision. Their exclusive prey at this stage are barnacles their own size, which they neatly drill with a special scraping organ, the radula. Aided by a slightly acid secretion to soften the prey's shell, the radula is used both to drill and to extract meat. Like other predatory gastropods, such as the cassids (*see* "Murder and Mayhem in the Miocene," *Natural History,* August 1991), they bore a hole a few tenths of a millimeter in diameter and then insert a trunklike proboscis and rasp to scrape out the prey from the inside. Only after they have begun to feed in this manner do they begin to deposit a white fringe of definitive adult shell.

During the first sixty days, the insatiable little locos grow to ten millimeters long, eating their way through as many as five barnacle species on the rocks, without discriminating among them. The little brown larval shell remains embedded in the larger, permanent adult one as a relic of the snail larvae's oceanic voyage and rocky landing. As long as the young locos feed on barnacles, the shell remains white. If they are fed mussels, which they accept with gusto upon reaching ten millimeters in length, the new shell turns black.

Many young locos I have collected in the field have white shells, while older ones are dark—suggesting a history of first feeding on barnacles, then switching to mussels or other prey. Upon settling onto rocky bottoms, the postlarval snails have pitch-black body tissues, but change to almost pure white during their first two weeks of bottom dwelling. Two months later, the body begins to take on the gray pigmentation of adults. Their inconspicuous coloration helps protect the elusive young; in addition, many of them often hide within empty barnacle shells.

My long-term research goals in Chile include learning how to save locos from extinction and perhaps one day reseeding their natural beds for managed commercial harvesting. Although many people are tempted to buy the banned loco meat, I sense a rising concern for conservation among the Chilean people. Recently, the Chilean legislature passed a new fisheries law that should begin to protect the country's coastal resources. In the Caribbean, parallel efforts are being made to protect and culture the queen conch (*Strombus gigas*), a once-plentiful mollusk that has suffered similar declines in population in recent years.

There is a certain enchantment in imagining the tiny loco larvae floating on their "gossamer wings" for hundreds or even thousands of miles, surviving the multiple perils of their frail life in the planktonic soup, as they have for millions of years. Loco fossils have been found in South Africa, and remains of related, extinct *Concholepas* species are known from other widely scattered sites around the world. But *C. concholepas* has existed essentially unchanged on the Chilean coast for about two million years. We are only now beginning to appreciate its cycle of reproduction, dispersal, and return to its favored habitat. If my hopes are realized, our work here with the Chilean National Fisheries Service will enable the loco to continue its ancient cycle into the future.

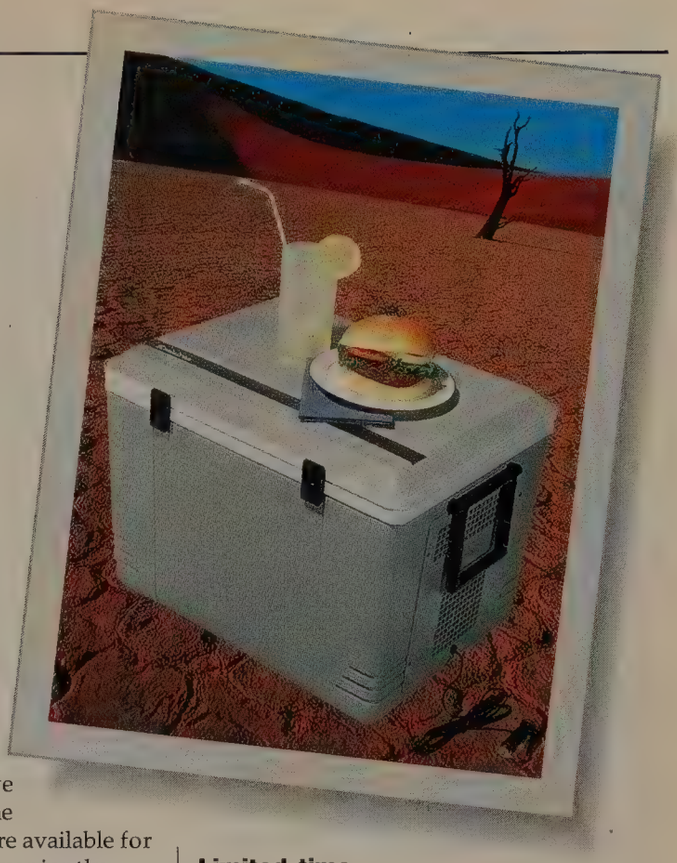
Louis H. DiSalvo earned his Ph.D. in environmental science from the University of North Carolina and now specializes in marine microbiology and aquaculture. He is a consultant to government agencies and fisheries in Chile, where he operates an independent marine laboratory.

TECHNOLOGY UPDATE

500 miles from nowhere, it'll give you a cold drink or a warm burger...

NASA space flights inspired this portable fridge that outperforms conventional fridges, replaces the ice chest and alternates as a food warmer.

By Charles Anton



Recognize the ice cooler in this picture? Surprisingly enough, there isn't one. What you see instead is a Koolatron, an invention that replaces the traditional ice cooler, and its many limitations, with a technology even more sophisticated than your home fridge. And far better suited to travel.

What's more, the innocent looking box before you is not only a refrigerator, it's also a food warmer.

NASA inspired portable refrigerator. Because of space travel's tough demands, scientists had to find something more dependable and less bulky than traditional refrigeration coils and compressors. Their research led them to discover a miraculous solid state component called the thermo-electric module.

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Think about your last trip. You just got away nicely on your long-awaited vacation. You're cruising comfortably in your car along a busy interstate with only a few rest stops or restaurants. You guessed it... the kids want to stop for a snack. But your Koolatron is stocked with fruit, sandwiches, cold drinks, fried chicken... fresh and cold. Everybody helps themselves and you have saved valuable vacation time and another expensive restaurant bill.

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And because there are no temperamental compressors or gasses, the Koolatron works perfectly under all circumstances, even upside down. Empty, the large model weighs only 12 pounds and the smaller one weighs just seven. Full, the large model holds up to 40 12-oz. cans and the smaller one holds six.

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The refrigerator from outer space.

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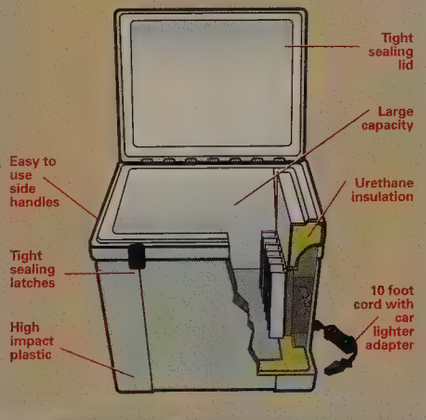

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A Texas Powwow

The Alabama and Coushatta Indians make no apologies for their eclectic traditions

by Samuel M. Wilson

It is pouring rain outside the Inn of the Twelve Clans on the Alabama-Coushatta reservation in east Texas, and no one is eager to leave. Because of the rain, the afternoon's gourd dances, which were to have been held in the powwow arena at the community center baseball field, have been moved into the gymnasium. Whenever the restaurant door swings open, the drum can be heard in the distance. The dancing last night had gone on until after midnight, and there was a five-mile run at seven this morning, so more than a few are willing to linger over lunch, saving their energy for the evening's dances.

Jack B., a member of the Alabama tribe, sits at a formica table and counts through his children and grandchildren. One of his seven children married a Pawnee, one an Omaha, a few married non-Indians. Everything he says is accompanied with quick, strong gestures. "He went away, became an outsider," he says, sweeping his arm toward the restaurant door. (I look.) "But he might come back, maybe to retire," he continues, pointing to his chest. Speaking of an aunt, he presses three fingers hard against his left palm and tells us, "She came back here a couple of years ago, but she died."

As we sit in the inn, the people at the table are constantly coming and going. Jack's son needs car keys. Jack's sister stops by (but is soon called away by a relative). A young woman who lives off the reservation and works for the *Houston Post* drifts by a couple of times. Her T-shirt has a raccoon on it, and several people make the connection—her nickname is Sawa, "raccoon" in the Alabama language. John Humano, Sr., one of the powwow (dance ceremony) officials, sits for a while. Someone mistakenly introduces him as a Kiowa Apache and is corrected by a chorus; he is Comanche and his wife is Kiowa. He likes to say he's a "Kiowa captive." As people come and go, the joke is repeated a few more times.

The conversation drifts somehow to languages. English is not Jack's first language or probably his second, since he speaks both Alabama and Coushatta. Maybe it is not even his third, since his mother was half Choctaw and he speaks that tribe's language, too. All of these are languages in the Muskogean family, which includes Creek, Chickasaw, and others spoken by the Native Americans of the Southeast. Jack counts from one to ten in Alabama and then in Choctaw and observes that the number eight is practically the same (*ontotchiina* in Alabama, *untuchina* in Choctaw). He notes that knowing one of the languages makes the others easier, although in his opinion, things in Choctaw are sometimes said backward.

Thirty years ago, someone notes, none of the kids entering first grade spoke any English, so they were often held back a year or two. Jack nods. Now most children know English well by the time they enter school. They also understand Alabama or Coushatta, but many will not use these languages unless they have to when speaking to older people. Even so, much of the discussion taking place at surrounding tables is in Alabama or Coushatta.

At the time of first European contact, the ancestors of the Alabama-Coushatta lived along the major rivers of central Alabama—the Coosa, Tallapoosa, and Alabama. Hernando de Soto must have met some of them in his meandering expedition through the Southeast in the early

Drummers ride in the powwow parade.
Samuel M. Wilson

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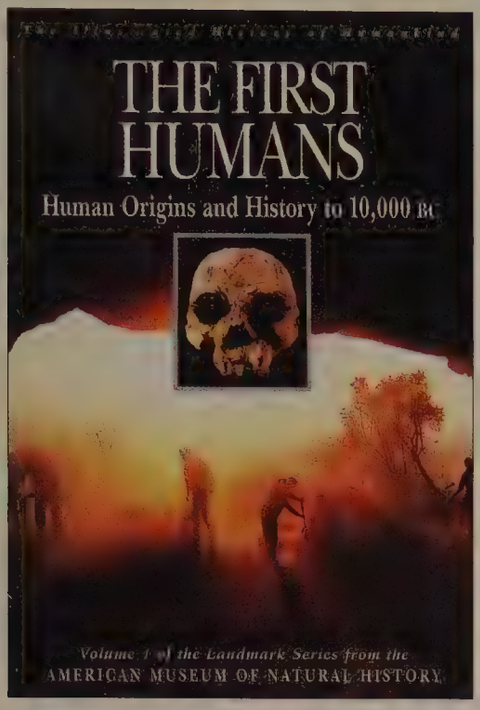
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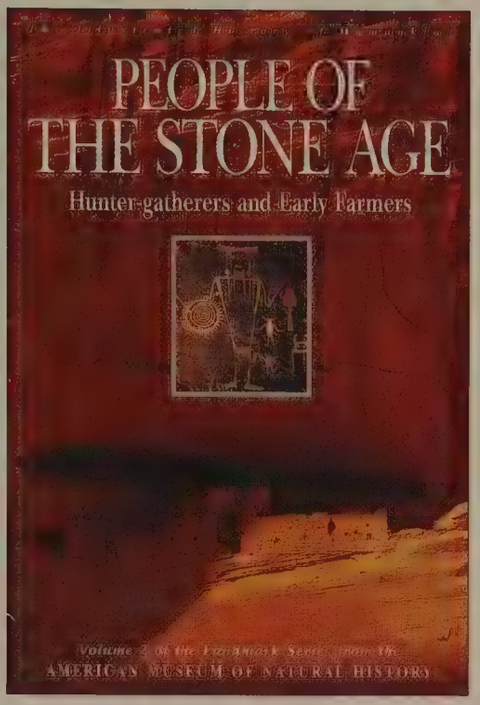

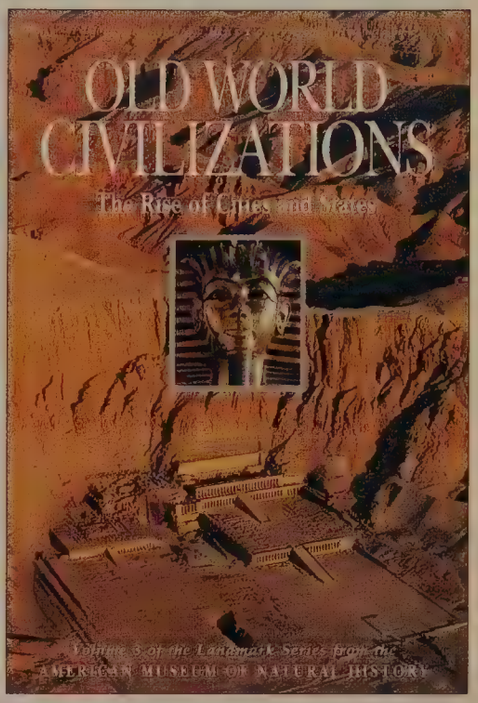

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General editor **Göran Burenhult** is associate professor of archaeology at the University of Stockholm.

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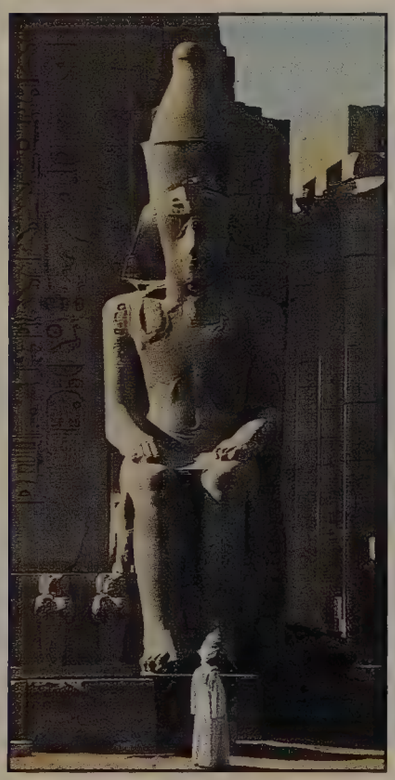

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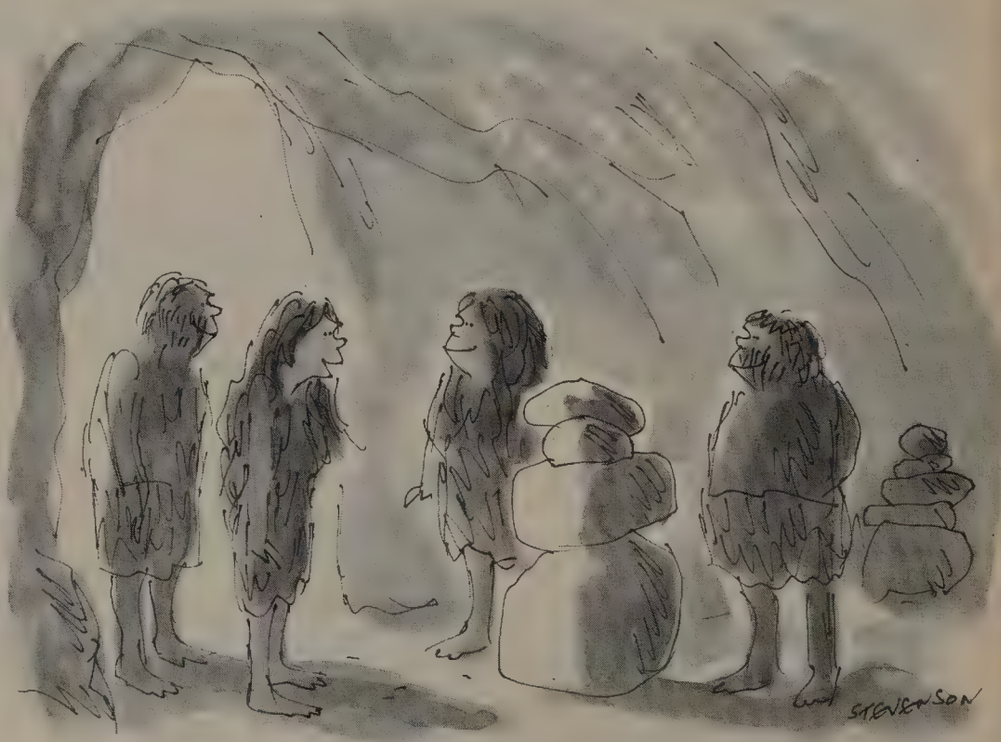
1540s. Documents and maps from the early 1700s show the location of "Alibamu" and "Kosati" villages still in this territory. But under increasing pressure from British and other European colonists moving west in the mid-1700s, the Alabama and Coushatta moved to lands in Louisiana and east Texas.

Thus the Alabama and Coushatta were settled in Texas in the late 1700s, before Anglo-American colonization of the region (the battle of the Alamo was in 1836). By the late 1820s, they had asked the Mexican government for permanent possession of their lands, and after Texas became an independent republic in 1836, the well-established and prosperous Alabama and Coushatta were the only groups to be exempted from a purge of Native Americans. They again escaped the fate of so many Indians of the southeastern woodlands, who were forced to move to the Oklahoma Indian Territories in the 1830s (the Cherokee "trail of tears" was just one such forced relocation). As a result of their unusual history, the Alabama-Coushatta reservation is somewhat isolated from other areas with large Native American populations.

Next to the gymnasium where the dance drum is beating lies the Alabama-Coushatta cemetery, surrounded by the tall pine and oak forest of the Big Thicket, as this part of east Texas is called. Some of the headstones date back to the mid-1800s. Back in the woods is the grave of subchief Colabe Sylestine, who in the nineteenth century helped lead the Alabama and Coushatta to their present home in Polk County and who signed the agreement with the state of Texas granting his people their land. Elsewhere in the cemetery, the short flagstaffs of long-since-dissolved flags lean against the headstone of McConico Batisse (1875–1951), a former chief of the Alabama. A razor, a tin coffee cup, and the shell of a flashlight sit along the line of the grave. The rain has washed away some of the gray sand around them, creating little pedestals for these characteristic possessions of the deceased.

Henry Steel, a Kickapoo from Oklahoma, was master of ceremonies for the first night of dances at the powwow last night. He may have been asked because of his "gift of gab," and rightfully so. He delights in intertribal jokes and camaraderie: "We're going to have three intertribal songs; in my language that's *niiswikwaa,* for you Comanches that's *tres,* and for you Cherokees"—holding up three fingers—"it's this many."

For an hour or more before the "grand entry," men, mostly older ones, performed the gourd dances. In front of the improvised benches that enclosed the dance circle, they danced slowly in and out to the music from the singers and drummers; some occasionally paused to shake hands and talk with one another in groups of two or three. They wore different versions of "traditional dress," some simply jeans and a western-cut shirt with a long, narrow sash tied around the waist and another sash over the shoulders. Each carried a



"Oh! I love Precambrian."

feathered fan in his left hand and shook a gourd rattle in his right.

Sitting at the center of the dance circle on metal folding chairs stenciled ACIR (Alabama-Coushatta Indian Reservation), a half dozen men sang and beat a large skin drum. Around them sat three or four women, also singing, and a few restless children who had to stay beside their parents or grandparents. Known collectively as the Drum, the people who sing and beat the drum are the soul of the powwow; they can carry on for hours without breaks.

Meanwhile the dancers for the evening's main ceremonies were getting ready. Some of the powwow dances involve competition in costume and dancing, putting personal status, skill, and grace to the test. For the mostly younger participants in these competitions, the dances also carry overtones of courtship and romance. Some of the evening's most impressive choreography took place in the parking lot as parents, often while dressing themselves, helped their restless children into elaborate outfits with headpieces, moccasins, and other components. The M.C. chastised everyone for the delay in the grand entry: "We're running late. We're twenty-two minutes into Indian time."

Miraculously—at a time determined by them and not by the M.C.—the milling horde became an ordered procession. An honor guard of war veterans entered the dance circle first, carrying the flags of the United States and Texas and a flag commemorating MIAs. The head gourd dancer, John Dart (another visitor from Oklahoma), came next, followed by the princesses of the Alabama and Coushatta tribes, both high-school seniors. Some other "royalty" followed. The women in buckskin regalia entered next, then women wearing "southern shawl costume," or "southern cloth dress"—silk or satin dresses in muted blues and reds, with bonework or beadwork draped over their shoulders and hanging down in front and back, a tasseled shawl over their left arm, and a feather fan in their right hand. Next came women in "northern shawl costume," a similar dress, but with the tasseled shawl unfolded and draped over their shoulders, a style more suited to exuberant dances favored by the younger women. Others wore "jingle dresses" covered with hundreds of shiny metal bells.

The men followed in "traditional dress," a diverse category of regalia that usually included a three-foot circle of tail feathers worn behind the hips. They wore

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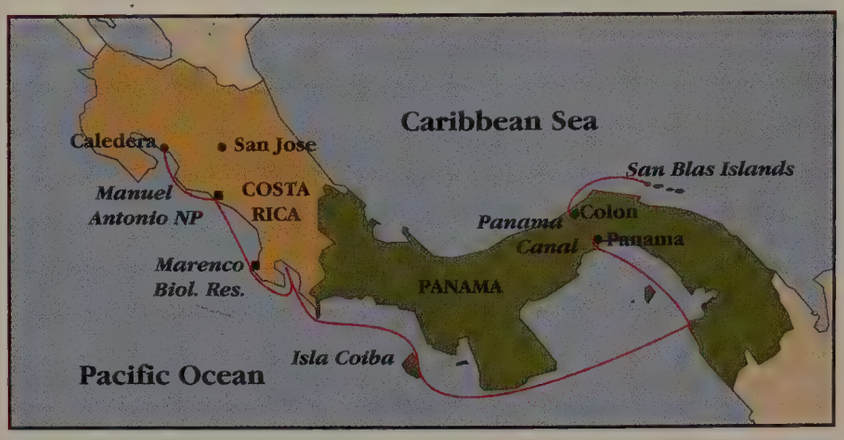

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moccasins, a breechcloth, a headdress of fur or a few upright feathers, bonework or colored beadwork, breastplates, armbands, legbands, and face paint, and usually held a short, ornate staff in the right hand. One man wore a wolfskin cape, with the wolf's head coming out over his forehead. His face was painted with wide, vertical white stripes, and he danced in a distinctive crouching, staccato step.

Then came the "fancy dress" dancers, whose costumes were flamboyant elaborations on the men's traditional dress. Their dance was the most athletic of all, and their regalia was designed to amplify every movement. In addition to the bustle of tail feathers, they had another circle of feathers around their shoulders, all of them tipped with streamers. The feathers and other parts of the costumes were dyed in brilliant colors. Sequined shoes, neon colors, and chromed bonework showed that innovative decorations were not discouraged.

Now, dyed feathers, beadwork, bone chest-plates, and huge bustles of feathers were admittedly not part of Alabama or Coushatta dress in centuries past. Some of the tedious cognoscenti of the powwow circuit lament this loss of tradition and deride the incorporation of Plains Indian dress as well as completely novel styles. But so what if these are not the sorts of clothes the ancestors of the Alabama and Coushatta wore? People of European ancestry no longer wear powdered wigs, knee breeches, or big-buckled shoes. Why should the distinctive powwow costumes, one of the most exuberant expressions of Native American creativity, be held to any different standard?

After the grand entry came the "tiny tots" competitions. Their regalia was something like that of the older participants, but with Mickey Mouse disposable diapers instead of breechcloths. Things slowed a bit, with feathered headpieces slipping down over eyes, and armbands and sashes being shed as fast as parents could put them on.

Quite a few of the spectators wandered over to the booths to get something to eat. Frybread is a staple on the Alabama-Coushatta reservation. It is bread dough formed into a thin slab about five inches across, then slipped into a frying pan of hot oil. The result is something like a chewy, unsweetened doughnut without a hole. Topped with beans, cheese, and lettuce, it becomes an "Indian taco."

After a few other competitive classes came the ladies' southern shawl dance, a

subtle exercise that lacks the spinning and shaking of the fancy dancers. This contest had the most dancers, spanning the greatest range of ages, with women in their fifties and sixties competing with those in their teens. The drum started and the dancers moved slowly forward, clockwise, as if walking carefully through the dark, trying to see who was there or to find something they lost. The tassels of the folded shawls draped over the dancers' left arms raked back and forth, and the beadwork down their backs swept back and forth to the same rhythm. In her motionless right hand, elbow bent, each dancer held a feather fan. After three great beats on the drum they danced lower, the fringes of their shawls nearly touching the ground. Two songs were needed for all the southern shawl dancers to compete.

Among the evening's dances, the most exciting was the Tracy Batisse Memorial Competition for male fancy dancers. At smaller powwows during the year, the dancers had competed to get into the finals for this competition, whose prestige far exceeds the $1,000 cash, silk jacket, and other things that come with winning. The four finalists all seemed to be about eighteen to twenty years old. They had been wandering around behind the bleachers for the previous half-hour, stretching, looking up in the air, turning away friends who wanted to talk, and shaking their shoulders and fingers like sprinters waiting for their call to the blocks.

About 2,000 people were watching the dances, the majority of them Indians. About 500 were Alabama and Coushatta living on the reservation; perhaps another 1,000 lived away but had come back for the annual powwow. Other Native Americans present included Chickasaw, Cherokee, Choctaw, Seminole, and Creek from Oklahoma and, from farther away, Sac, Fox, Comanche, Kiowa, Lakota, and Shoshone. Many non-Indians had also come, some from neighboring towns and some from great distances, to enjoy the dancing and the welcoming atmosphere of the powwow.

No one was getting frybread now. The M.C. called for a "contest dance," and the Drum started off at an exhilarating pace. The fancy dancers shook the tassels streaming from their shoulders and hips, spinning the tasseled batons looped around their wrists. Leaping and turning, they looked like a flurry of feathers. They danced the same dance, but each added his own new moves. Girlfriends and family sat around the dance arena, arched forward, clenching their fists.

The Drum's rapid pace slowed for three intense beats, and with them the dancers all flew downward into a low crouch, jumping three times. The participants' passion, and the focused hush of the crowd, made it plain that this was no show for tourists. The annual powwow is the event all the Alabama and Coushatta try to come home for, and this dance is its centerpiece. The dancers are competitive, to be sure, but together they reflect a commitment to Alabama and Coushatta identity and tradition.

The Drum then launched into a furious tempo, taking the dancers with it. Finally the Drum ended the song with a great flourish, leaving the four finalists reaching for the sky, dripping sweat and exhausted, feathers quivering and tasseled batons twirling high above from both wrists. A storm of applause burst from the crowd, as the M.C. quipped, "Well, gentlemen, that was a good warm-up song—now let's start the competition!"

Samuel M. Wilson teaches anthropology at the University of Texas at Austin.

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Caroni Swamp, Trinidad

by Robert H. Mohlenbrock

On Trinidad's western coast, about five miles south of the capital city of Port of Spain, lies Caroni Swamp, a forty-square-mile stretch of swampland intersected by numerous water channels. Fed by freshwater that drains down from the island's Northern Range and Central Hills, this wetland is also bathed by seawater from the Gulf of Paria, which separates Trinidad from the mainland of Venezuela. Twice every twenty-four hours, the tide brings in saltwater, which mixes with the fresh. The major estuary is the Caroni River, which receives water from its mountain tributaries and flows westward through the Northern Basin before dividing into a number of distributaries that meander through the swamp.

The salinity of the swamp is especially high during the dry season, from January to April, when there is little rainfall. The salt content in the water may reach twenty-five parts per thousand, compared with about thirty-five parts per thousand for seawater. During the rainy season, from June to December, the ratio may drop to as little as six parts per thousand. Very different circumstances prevail in Nariva Swamp, on Trinidad's eastern coast, where the steady supply of water from the Nariva River maintains a freshwater swamp forest (*see* "This Land," October 1993).

With its mangrove stands and open areas dominated by grasses and sedges, Caroni Swamp presents an impression of wilderness, but it has been altered by occasional disturbances. As part of a 1921 land-reclamation scheme, various drains and sluices were excavated. The Princess Margaret Highway, which is now Caroni's eastern border, was constructed on reclaimed land. Seven canals were subsequently cut east to west, to increase water circulation.

Tour companies provide boat trips into Caroni Swamp, and I was fortunate to obtain the services of Winston Nana, one of the boat operators who also happens to be a knowledgeable naturalist. In a large, flat-bottomed boat, we meandered through continuous stands of mangrove trees, following an intricate network of estuaries and lagoons.

Kevin Schafer

Red mangroves grow along the seacoast of Caroni Swamp, below. Opposite page: A tricolored heron is one of 150 bird species that frequent the swamp.
Gerry Ellis

Caroni Swamp
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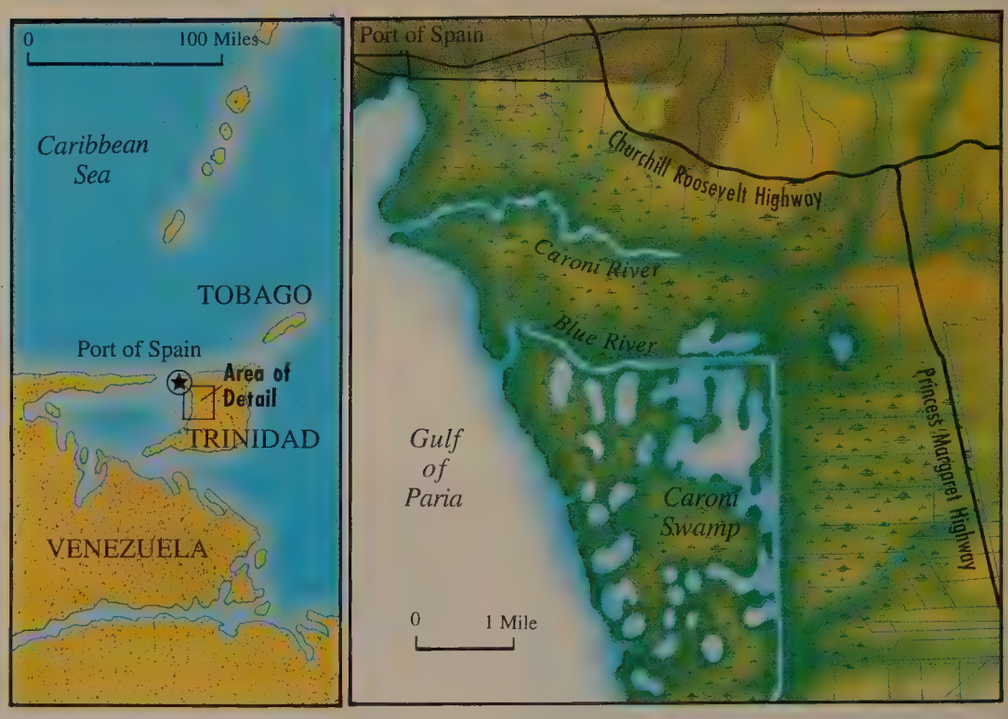

Joe LeMonnier

Winston Nana showed me how to distinguish between the seven different species of mangroves that grow in Caroni Swamp. The most numerous are three species of red mangroves, which tend to form the borders of the waterways. Red mangroves are unusual in the plant kingdom in that they are viviparous—that is, they disperse growing young instead of dormant seeds. Following flowering, pollination, and fertilization, the mangrove produces long, spindle-shaped seedpods, each containing a single seed. While still on the tree, the seed within the pod germinates, and the pod splits open, exposing the young leaves. When the young plant is sufficiently developed, the pod with the seedling finally falls from the parent tree, the pod's pointed end burrowing into the mud. Spongy roots soon grow from this buried point.

Each evening, scarlet ibises return from their feeding grounds to roost in Caroni's mangroves.
Art Wolfe

By a process called reverse osmosis, the roots take up water and needed nutrients while excluding much of the salt. If excess salt enters the plant, it can be stored in the leaves. In this way red mangroves can tolerate a high degree of salinity. The trees also send down hundreds of prop roots that provide anchorage in the murky, watery soil.

Particles of soil and silt that get caught on the prop roots may, over time, form a thick deposit of soil. For this reason, botanists have long regarded red mangroves as pioneer species that build land along tropical coastlines. More recently, however, researchers have noticed that seedlings of black mangroves and white mangroves may also colonize new sites. And ecologist F. E. Egler has even shown that red mangroves sometimes spread landward instead of seaward. Thus some ecologists prefer to regard red mangroves as land stabilizers, rather than land builders.

Two kinds of black mangroves grow in Caroni Swamp, usually on firmer ground than the red mangroves. Beneath the black mangroves are dozens of slender, woody, straw-shaped outgrowths from the root system. Called pneumatophores, these projections store nutrients as well as provide additional support and anchorage for the plants. The triangular pods containing single seeds of the black mangroves are not viviparous, but fall to the mud beneath the tree and are transported by tides to other muddy areas where the seeds may germinate. A white mangrove and a buttonwood mangrove complete the array of mangrove species at Caroni Swamp.

Animal life abounds in the swamp. At low tide, the mudflats are alive with fiddler crabs, blue crabs (a delicacy Trinidadians make into callaloo soup), and a purplish crab that grows to a length of sixteen inches. The purplish crab feeds on the many oysters and barnacles found on the mudflats. Many of the red mangrove's prop roots are covered with tree-climbing crabs, which consume the algae that periodically inundate parts of the swamp. Raccoons stealthily make their way around the prop roots, looking for a meal of crabs. A small crocodilian known as the spectacled caiman may haul itself out of the water to bask. The silky anteater, nearly two feet long at maturity, roams about to forage at night but spends the day up in a tree, curled around the branches.

About 450 acres within the swamp have

been set aside as the Caroni Bird Sanctuary. The star attractions are the 3,000 scarlet ibises that, near sunset, fly from adjacent Venezuela into Caroni Swamp and perch or nest in the tops of mangrove trees.The pink birds that accompany them are juveniles, whose colors will intensify after three years.

Scarlet ibises have a wingspan of thirty-one inches and are thirty-seven inches long from the tip of the bill to the tip of the tail. There are six nesting and roosting colonies at Caroni, much fewer than existed twenty-five years ago, when 10,000 scarlet ibises lived in the swamp. The birds build their nests in the crowns of mangrove trees, cementing together pieces of twigs with their own droppings.

Another bird that nests in the mangroves is the yellow-throated spinetail, named for its relatively long, slender tail. Spinetails feed on insects and spiders, sometimes jumping into the air to catch flying insects.

Altogether some 150 kinds of birds visit Caroni Swamp. Other birds that Winston Nana helped me identify on my excursion included snowy egrets, great blue and tricolored herons, lesser yellow-legs, black-bellied plovers, whimbrels, willets, and a green-rumped parrotlet. But perhaps the most peculiar was the potoo, which has very short legs and a tail about as long as its body. A nocturnal bird related to nightjars, the potoo spends its day sitting erect on a branch, with its head and bill pointing upward. In this posture, it looks like a twig. At night, the potoo flies from its perch to capture insects, returning to the perch to devour them.

More than eighty kinds of fish have been found in Caroni's estuaries and lagoons. One of the most amazing is the four-eyed fish *Anableps,* which can see both above and below the water surface. I saw a school of them swimming, and their eyes looked like bubbles on the water. *Anableps* actually has only two eyes, but they are divided by an epithelial line into upper and lower portions, each with its own cornea and retina. When the fish swims with its eyes at the waterline, it can see objects in focus both above and below. Apparently the above-water view enables the fish to keep an eye out for predators; it seeks its own prey underwater.

This month, Robert H. Mohlenbrock, professor emeritus of plant biology at Southern Illinois University, Carbondale, takes a break from his usual beat, the 156 U.S. national forests.

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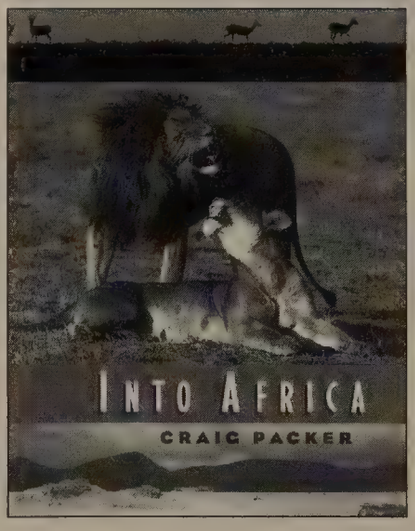

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Sticker Shock

Beware the ties that bind

by Roger L. Welsch

I collect and repair old tractors—to be exact, Allis Chalmers WC tractors from the late 1930s. It's more than an avocation: dismantling and reassembling old Allises is my therapy, my retreat, my obsession. At this point I have…well, I have more orange Allises than I would like my wife to know about.

The thing is, parts for old tractors are hard to find, and therefore expensive, so I am always looking for another Allis WC, mostly to cannibalize for parts. Every now and then someone tells me he has an old one sitting back in the wood lot and he'll let me have it for a hundred dollars or so.

As you can imagine, any piece of iron that has been sitting back in the trees for a couple of decades develops a good case of rust; in fact, most of the tractors I acquire have over the years become a ton and a half of solid rust. Pistons are stuck (in contrast to automobiles, which have "engines" that "seize up" or "freeze," tractors have "motors" that "stick"), valves are stuck, crankshafts are stuck, transmissions are stuck…carburetors, magnetos, steering assemblies, throttles, controls, plugs, pumps, bearings, seals, gears, lugs, screws, bolts, nuts…all stuck. Rare is the day, therefore, that I am not occupied with the process of getting something *un*stuck.

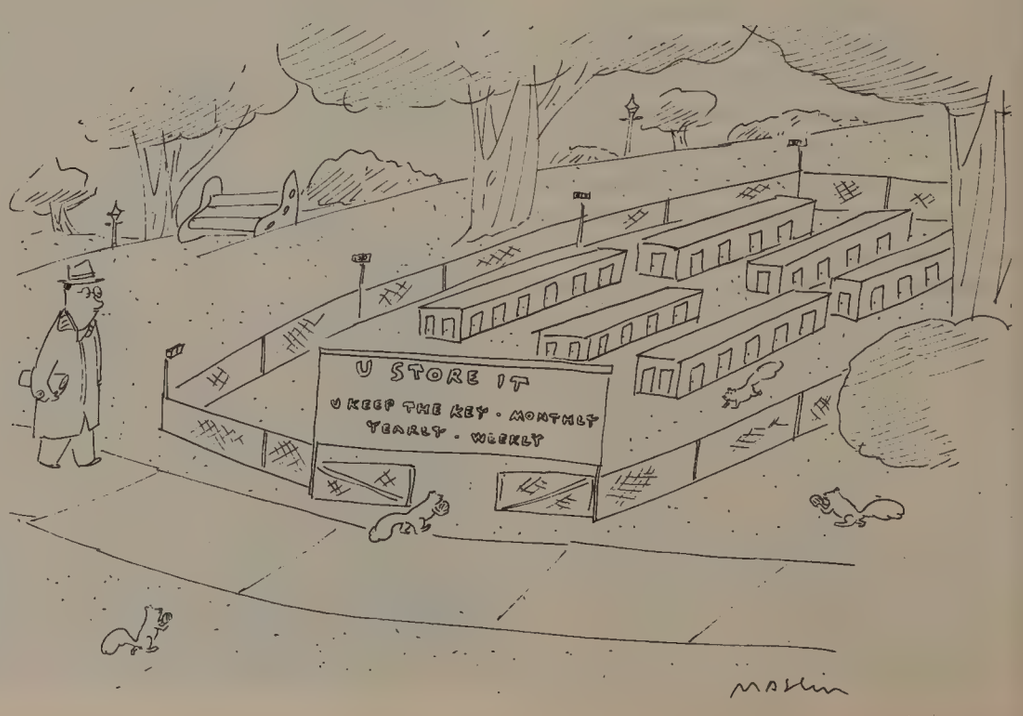
I'm not alone. My conversations with friends in town often focus on exactly the same sort of problems. Farmers, mechanics, plumbers, electricians, bartenders, cooks—all trying to get things unstuck. And I am amazed at the variety of techniques that have been devised for getting things unstuck.

Tractor restorers and mechanics often have "secret" recipes for unsticking motors—blends of fine-grade olive oil, brake fluid, transmission oil, vinegar, kerosene, even Coca-Cola. I have listened in on endless conversations arguing the merits of one formula or another. I pretty much adhere, so to speak, to commercial unstickers like WD-40 or Liquid Wrench, which I would buy in 60-gallon drums if I could find a source. Anything to get rid of whatever it is that sticks motors. And in addition, of course, one wants some reliable substance to keep them unstuck.

Mine is the quest that drives a good part of modern technology and warfare, and that drove ancient technology and warfare as well—how to keep your own stuff unstuck and how to get the other guy's stuff stuck. Tank treads let your army move without getting stuck; tank traps snarl up the enemy's tank treads so they do get stuck. Oil, grease, graphite, bearings, exotic "slick" materials—all have been developed to keep chariots, catapults, guns, airplanes, and rockets rolling and sliding. The Allied bombing effort against Germany, on the other hand, was concentrated on the ball bearing plants at Rostock, to keep the blitzkrieg from rolling along smoothly—and at Ploesti, to deny the Axis the oil to lubricate whatever bearings they did get made. Sticking, unsticking, sticking, unsticking. That's the true dialectic of history.

If this sounds like the sort of simplification an outsider to military thinking might come up with out of ignorance, please note: (1) I am not exactly a novice at military tactics, having been a staff sergeant in the Nebraska Air National Guard at one time; and (2) military researchers acknowledge my thesis in their own nomenclature. They speak of "slick'ems" and "stick'ems," further classified as NLWs, or "nonlethal weapons." No kidding. Slick'ems slow things down by making them *too* slippery: they render roads, bridges, and railroads so slick that both motor traffic and foot traffic are stopped dead—it's like trying to move on ice.

A new stick'em, on the other hand, was recently described in *Newsweek* (February 7, 1994) as "a sticky foam that slimes.… Fearsome gunk, it quickly turns to taffy when exposed to air.… Bad guys would be stuck until sprayed with solvent." The



Rand Corporation's Bruce Hoffman described the stuff as "a polymer adhesive that you drop from a plane or spray on a road, and things just stick. If you glue down the Serbs' artillery, what are they going to do, just throw their guns down and walk away? And could they? The problem is, people stick to it too."

Some folks outside of the military are already licking their chops at the idea of getting their hands on this technology. For example, police want to stop miscreants dead in their tracks by zapping them with a canister of super stick'em or greasing the skids into the slammer with a good dose of slimy slick'em. I love the idea of a bunch of muggers wadded up in a ball of goo for a couple of days; just the company should be punishment enough, not to mention the, er, inconvenience, if you catch my drift.

Before long, of course, whatever advantage the good guys have will wind up in the arsenal of the crooks. Police would have to carry not only cans of stick'em to nail crooks caught red-handed but also a can of *un*stick'em in case the situation deteriorated into a running goo battle and an officer was gooed by hostile or even friendly fire.

As for us civilians, the world could definitely become a less friendly place if this stuff fell into the wrong hands. I would fight to the death to defend my right to bear slick'em in well-regulated tractor repair but is there really an argument for public, over-the-counter access to stick'em? Will the NRA say, "When stick'em is outlawed, only outlaws will have stick'em"?

If the terrible potential of all this is not dealt with seriously, and I mean now, the words, "Stick 'em up," may take on a whole new importance.

Folklorist Roger L. Welsch lives on a tree farm in Dannebrog, Nebraska.

Why Are More Ants Not Uncles?

John D. Dawson, Courtesy of the National Geographic Society

"The workers of a typical ant colony are all daughters of the queen. The males, her sons, are generated after the worker population is well established and before the mating season. They live for only a few weeks or months, they do no work, and apparently are tolerated solely for their ability to transmit the colony's genes. Males are thus drones in the original Old English sense of the word: *drons,* parasites who live on the labor of others. They are also drones in the modern technological sense: flying sperm-bearing missiles constructed only for the instant of contact and ejaculation."

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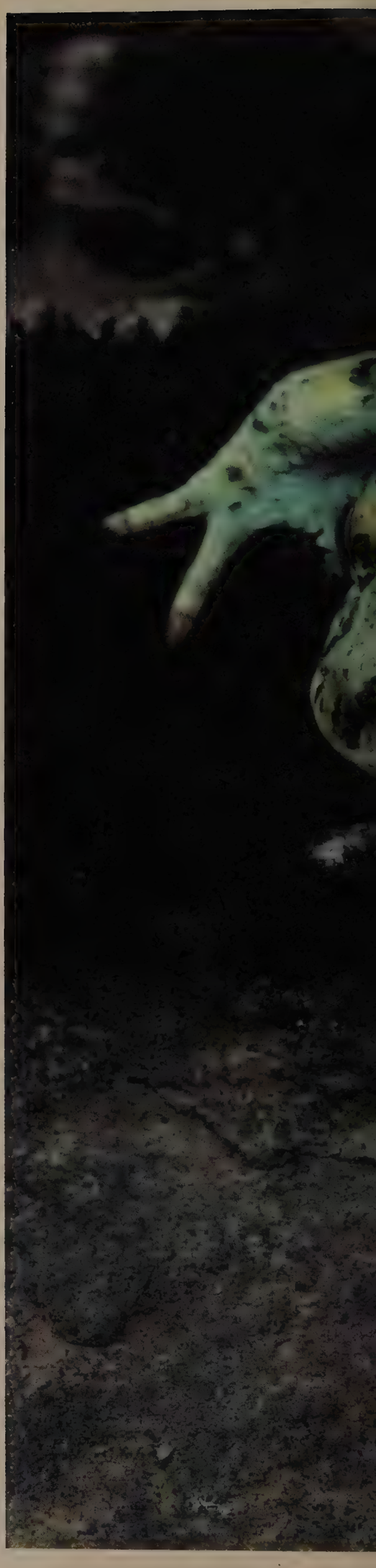


Amphibians in a Bad Light

What is killing the eggs of Oregon's western toad?

by Andrew R. Blaustein

Each spring, two or three times a week, my graduate students and I travel eighty miles east, from Oregon State University to Lost Lake in the Cascade Range. Surrounded by snow-capped peaks and volcanic debris, the lake, at an altitude of about 4,000 feet, is the lowest in the area and consequently the first to lose its ice covering. And when the ice goes, western toads (*Bufo boreas*) immediately begin breeding by the hundreds. Because this can happen any time in May or June, frequent visits insure that we catch them in the act. But it is not easy; some years, when the snowpack is great, we have to snowshoe several miles around the lake to get to the breeding site.

This year, however, the snow around the lake melted by early May, so we could drive close to the small section of the lake that these amphibians seem to prefer. Toads began to emerge on May 6, the earliest date we had ever seen them arise from their six-month winter sleep. We donned our waders, picked up our pails, nets, scales, and notebooks, and ventured into the cold, clear water. After some searching, we found hundreds of toads.

To obtain a long-term record of their reproductive patterns and changes in their population size, we had been weighing, measuring, and marking western toads at Lost Lake since 1979. Nevertheless, we were still amazed at how the toads, in their quest to mate, scrambled over snow and ice and into near-freezing water. Close to the surface, where the toads congregated, violent winds and snow, accompanied by

Before the snow has completely melted in Oregon's Cascade Range, toads, frogs, and salamanders breed in the clear waters of Lost Lake, above. The western toad, right, is in decline throughout most of its range.

D. Grant Hokit

Edward R. Degginger; Bruce Coleman, Inc.

In shallow water, a single strand of western toad eggs, below, lies exposed to the sun's ultraviolet rays. Most salamanders, however, lay their eggs in deep water or other protected places. Inside their eggs, right, embryonic salamanders have already developed their feathery external gills.

Alan Blank; Bruce Coleman, Inc.

pelting hail, continued to buffet them while they bred.

Males arrived first, followed by females, and in a seemingly haphazard manner, hundreds of toads searched for mates. Because the males outnumbered females, the competition for access to females was intense and shoving matches often erupted. Soon after the pairs formed, the females began laying eggs and the males fertilized them by releasing sperm directly into the water. On average, each female produced some 12,000 eggs in long strips surrounded by a protective, jellylike covering. The individual strings stretched for more than twenty feet and often became intertwined with the shallow vegetation and with eggs deposited by other females. Three days after the toads began to converge on the lake, egg laying was complete and they disappeared into the forests to feed and fatten up before hibernating again in the early fall.

During peak years at Lost Lake, we have seen more than 500 pairs of toads, several hundred unpaired males, and several million eggs strewn about the lake, but this year we counted only 147 breeding pairs and about 100 unpaired males. Almost two million eggs were laid. As usual, the eggs, with their jet-black embryos, began to develop normally, but two days after they were laid, we began to see the same ominous pattern we had observed for the past several years at lakes throughout the Cascades. Many embryos began to turn white as they started to die in wavelike fashion from one end of the enormous egg mass to the other. Soon they became a putrid, decaying mess, attracting flies and other insects—a potential feast that lured Pacific tree frogs (*Hyla regilla*) to the site. Opportunistic garter snakes arrived next to dine on the frogs. A week after the toad eggs had been laid, only half of them were viable. After the normal developmental period of about two weeks, even fewer hatched as tiny tadpoles. And this was only a small part of a much bigger problem.

By the mid-1980s, we began to notice that the frogs and toads we had been studying were becoming more difficult to find. Some populations of the most common species, such as the Cascades (*Rana cascadae*) and red-legged (*R. aurora*) frogs and the western toad, were nowhere to be found. Through the grapevine, I learned that amphibians were disappearing in many parts of the world, from North and South America, Asia, Africa, and Australia. Some species were even reported to have become extinct. To add to the mystery, in some areas populations of certain species were doing fine, while others were disappearing. In Oregon, for example, Pacific tree frog populations were thriving in lakes and ponds where western toad and Cascades frog populations were dwindling.

Biologists proposed many possible causes for the declines, including habitat destruction, pollution, and natural population fluctuations, but no single reason was apparent. In many areas, including our study sites, declines were occurring in relatively undisturbed habitat with no apparent pollution. Yet by the late 1980s, a pattern began to emerge that gave us some clues to the puzzling egg deaths—and perhaps to the shrinking populations—in the Cascades.

A significant number of the troubled species were mountain-dwelling amphibians that laid their eggs in the open, in shallow water—the same way in which the declining Oregon species did. Throughout development, these relatively unprotected eggs would be exposed to sunlight and potentially harmful ultraviolet (UV) radiation. The middle portion of the UV spectrum, known as UV-B, is especially dangerous. In humans it can cause sunburn and skin cancer and weaken the immune system. UV-B can also damage amphibians. In the mid-1970s, a labora-

tory study conducted by Robert Worrest, at Oregon State University, showed that western toad embryos developed abnormally when subjected to UV-B radiation. Since then, several reports have documented a gradual increase in UV-B radiation hitting the earth's surface as the protective ozone layer thins. Were increasing levels of UV-B radiation responsible for the high rate of egg mortality in the Cascades? And if other declining amphibians had a similar vulnerability at the egg stage, could increasing exposure to UV-B radiation each spring be responsible for shrinking their populations over time?

In the late 1980s, when I first suspected UV-B radiation caused the toad eggs to die, I began a series of simple experiments to see if this was possible. I brought some newly laid western toad eggs to my laboratory and reared them in the absence of sunlight in aquariums filled with lake water. I followed the eggs' development until they hatched. Several months later the tadpoles metamorphosed into young toads. I was excited to see that almost all of the laboratory eggs survived, while eggs from the same clutches left to develop in the lake had died at unprecedented rates. Whatever the problem was, it did not seem to be in the eggs themselves.

After hearing about my ideas on UV-B radiation and amphibian declines, John Hays, a molecular geneticist at Oregon State University, called me to discuss how he might get involved. To learn how plants and animals repair UV-B damage to DNA, Hays had been studying the process in the eggs of African clawed frogs (*Xenopus*)—the amphibian equivalent of the well-studied laboratory rat.

When a cell is exposed to UV-B radiation, the energy can be absorbed by a number of biologically important molecules, including proteins and DNA. When this happens, the bonds between atoms and molecules can be altered, causing the cell's chemical machinery to malfunction. Such changes are particularly disruptive when they occur in DNA; if the genetic code, which carries the instructions for life, is misread, mutations and cell death can occur. Many plants and animals, however, are able to repair a certain amount of DNA damage. Photolyase, an enzyme found in the cells of many organisms, can remove the harmful defects. Hays reasoned that the eggs of different amphibian species may contain different amounts of photolyase. Therefore, we predicted that species with the greatest quantities of the enzyme would be more resistant to damage by UV-B than species with less photolyase. This could explain why the eggs of some amphibians were dying while those of others were unaffected.

The first step in testing our hypothesis was to collect eggs from a number of amphibian species with different egg-laying behaviors. We also made sure to include eggs from species that were in decline and from species that were doing well. Once eggs were collected, Hays and his chief technician, Peter Hoffman, measured photolyase levels, using the same techniques they had perfected while studying African clawed frogs.

The results of the molecular tests were compelling. The eggs of the nine species we examined showed enormous differences in the amount of photolyase they contained. Eggs of the Pacific tree frog (which are laid in open, shallow water) had the most photolyase: three times as much as the Cascades frog and six times as much as the western toad. The eggs of the six salamanders we tested had less than any of the frogs, with the least amount being found in Dunn's salamander, *Plethodon dunni* (Pacific tree frog eggs had eighty times more photolyase than these amphibians).

The correlation between levels of photolyase and egg-laying behavior was striking. The salamanders, whose eggs have little photolyase, generally lay their eggs under logs, in crevices, or in deep water—all places where little UV-B radiation will penetrate—while species that lay their eggs in the open, exposed to sunlight, had the highest levels of the enzyme. The egg-laying behavior of salamanders may not have evolved specifically to afford them protection from UV-B radiation; other selective pressures, such as predation and temperature requirements for development may have been more important. Nevertheless, the protection from UV-B

may be a secondary benefit. Those species that laid their eggs in the open, however, needed high levels of photolyase to minimize the damage to their DNA caused by exposure to direct sunlight.

Although the results of the enzyme studies were suggestive, we still needed to know if UV-B radiation was damaging eggs in nature. We began tackling this question even before we had the results of the DNA repair study. With field experiments in lakes and ponds where amphibians naturally lay eggs, we could compare the hatching success of eggs exposed to UV-B with that of shielded eggs. We gathered freshly laid eggs from four species that deposited them in the open: Cascades frogs, Pacific tree frogs, western toads, and northwestern salamanders (*Ambystoma gracile*). We placed the eggs in the bottom of screened, boxlike enclosures that allowed water to flow freely through them. Over some of the enclosures, we placed plastic filters that blocked UV-B. We left a second set of enclosures uncovered, exposing the animals in them to the rays. A third set, which had a plastic filter that allowed transmission of UV-B, provided a control to insure that any variation we found under the UV-B-blocking model was not due to the presence of a plastic cover.

We placed the enclosures randomly in the shallow water of lakes or ponds where natural breeding sites were located. By using four enclosures of each type, we insured that our results were not caused by some bias in our procedure or by a small sample size. Setting up the experiments at several different sites helped assure that any results we obtained were not unique to a particular area.

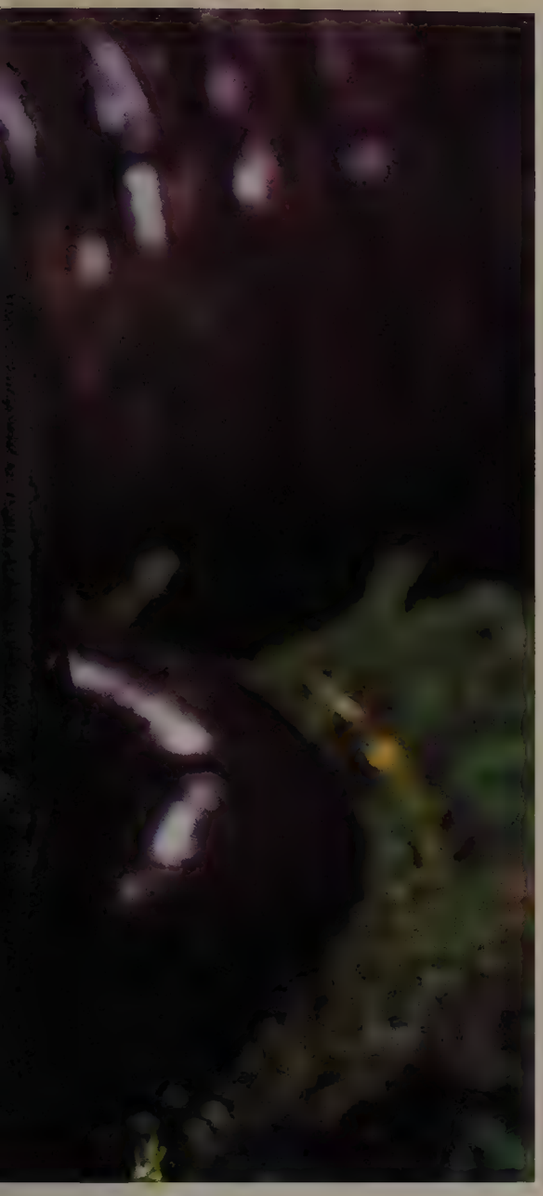
Although we only had to follow the development of the eggs until they either hatched or died, the experiments took two years to complete. Like most fieldwork, the project ran into some unexpected trouble. During the first year, we could not get enough viable eggs to set up our experiments because the animals did not breed at all sites. Spring storms with high winds destroyed some of our enclosures. Under the same harsh spring weather encountered by the toads, we had to count and measure each egg, in every enclosure, every day. And then there was vandalism, both by humans and smaller mammals. So someone had to guard each site, twenty-four hours a day, until the experiments were done, which often took two weeks. By the end of the second year, however, we had results that were both dramatic and foreboding.

More than 40 percent of the western toad and Cascades frog eggs exposed to UV-B radiation died, compared with 10 to 20 percent of those that were shielded. Northwestern salamanders did not fare better; more than 90 percent of their exposed eggs died. The Pacific tree frog, however, was unscathed, with almost all of its eggs surviving under all lighting conditions.

These results, together with those from the DNA repair study, convinced us that the link between UV-B radiation and the egg deaths was real. Natural levels of UV-B were killing amphibian eggs in the field. Pacific tree frogs—which had the highest levels of photolyase and whose populations were doing fine—seemed more resistant to UV-B than did western toads and Cascades frogs, two species with less photolyase that are in decline throughout their ranges. We do not know the status of northwestern salamander populations, but given our results, they too could be in jeopardy.

We had found one small piece of the amphibian decline puzzle. But many questions remain. Is the egg mortality in the Cascades caused solely by UV-B exposure or are other factors involved? We had observed the growing presence of a pathogenic fungus in the lakes. Is the UV-B radiation compromising the defense systems of embryos, making them more susceptible to disease? Another question is, how much mortality during the egg stage can a population endure before it crashes? Western toads, for example, live for twenty years or more, so the results of their reproductive troubles in recent years may not become apparent for many years.

Finally, could we settle on a universal explanation for amphibian declines? In-



Unlike most salamanders, the northwestern salamander often deposits its eggs in shallow water where ultraviolet rays penetrate.
D. Grant Hokit

creasing levels of UV-B radiation are obviously not the only reason these animals were disappearing. It cannot explain, for example, why species that live under dense forest canopies, protected from UV-B, are also in trouble. Perhaps other organisms, such as plants, fish, insects, and even humans will provide us with more information on the damaging effects of increasing levels of UV-B. We know, for example, that certain crop plants have reduced growth, photosynthetic activity, and flowering when exposed to UV-B radiation. In the Antarctic, severe ozone depletion and increased UV-B have been associated with reduced growth in phytoplankton.

If projected increases in UV-B occur, over evolutionary time there may be increased selection pressure on amphibians and other organisms to evolve efficient repair mechanisms or to alter their behaviors and thereby minimize their exposure to UV-B. Unfortunately, changes wrought by human disturbance occur at such rapid rates that many organisms may not have time to adapt. □

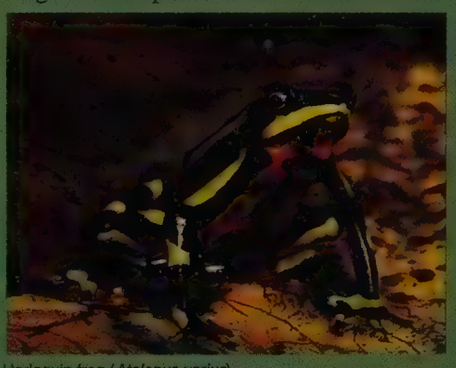
Here Today, Gone Tomorrow?

The impact of human activities on amphibians is difficult to gauge. Natural fluctuations in their populations and the lack of long-term data on their numbers have led to some uncertainty about their status. Nevertheless, an alarming number of amphibians are on the endangered list. Their semiaquatic life styles make amphibians particularly vulnerable to change; habitat destruction, which is probably the single most important cause for the decline of most species, affects amphibians both on land and in the water where they breed. Their permeable skin readily absorbs waterborne pollutants, they have no hair or feathers for protection, and their eggs are not encased in hard shells. In addition to habitat loss, a host of other factors—disease, water acidification, increased UV-B radiation, and introduced species in ponds and lakes—may be contributing to dwindling amphibian populations.

Golden toad (*Bufo periglenes*)
Gregory G. Dimijian; Photo Researchers, Inc.

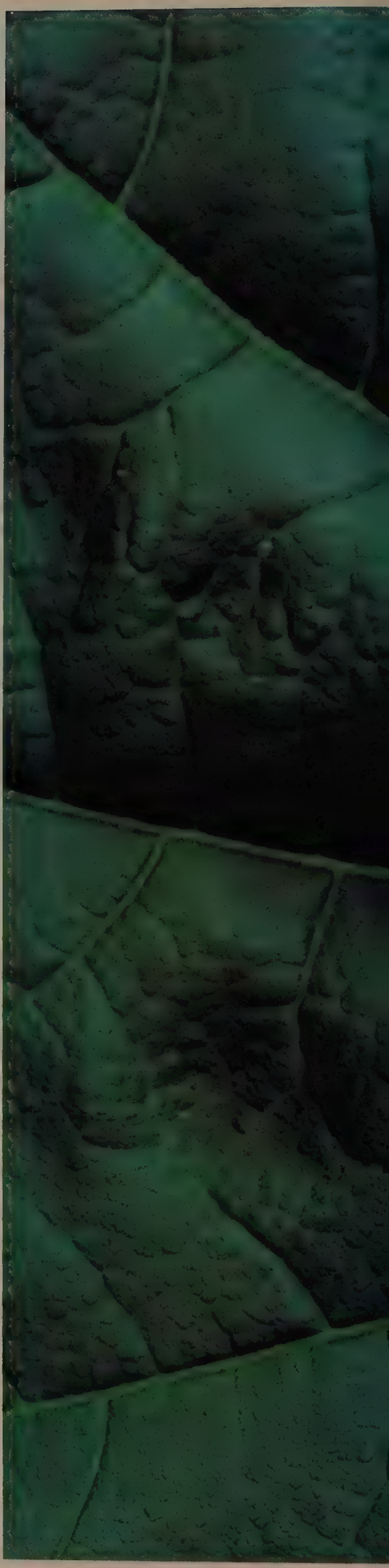
Red-legged frog (*Rana aurora*)
Frank Schneidermeyer; Oxford Scientific Films

Some of the more attractive and interesting toads and frogs are among the amphibians that are disappearing. Populations of the red-legged frog (*Rana aurora*), found from British Columbia to northern Baja California, have dwindled drastically in California and Oregon, but the cause of the decline is unknown. Australia's gastric brooding frog (*Rheobatrachus silus*) is one of the most fascinating amphibians because of its habit of brooding its offspring in its stomach and then expelling them as tadpoles or young frogs. This species was discovered in 1973 and has not been seen in nature since 1979. The golden toad (*Bufo periglenes*), seen here mating, is found only in Costa Rica's Monte Verde Cloud Forest Preserve; its range is a few miles along the crest of the continental divide. This diminutive toad was abundant in 1987, but is now extremely rare. The harlequin frog (*Atelopus varius*) has vanished from the same area.—*R. A.*



Harlequin frog (*Atelopus varius*)
Michael Fogden; Oxford Scientific Films

Australian gastric brooding frog (*Rheobatrachus silus*)
R. W. G. Jenkins; NHPA



A Pacific tree frog rests on a leaf. Although this species deposits its eggs in shallow water, high levels of photolyase, an enzyme that repairs UV-B damage from the sun, seem to protect them.
Art Wolfe

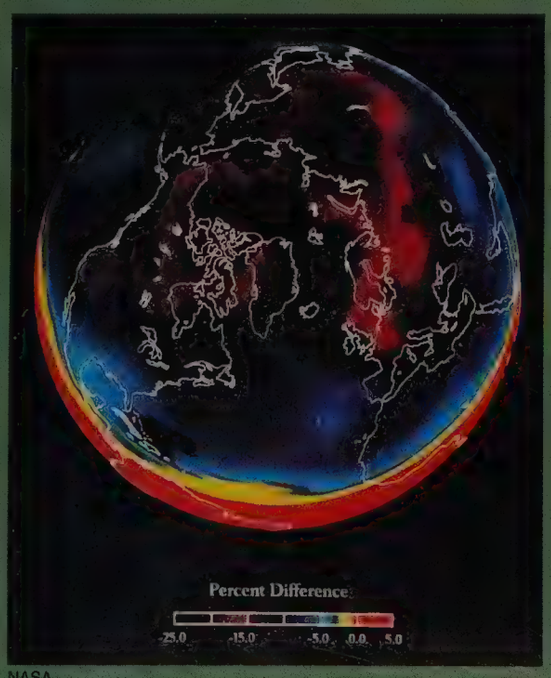
The Ozone Connection

The ozone layer is thinning, but how much is being lost over any particular part of the globe varies according to latitude and season. The computer-generated image below shows that significant losses have occurred over populous regions of Asia, Europe, and North America (demonstrating that the ozone hole over Antarctica is not our only problem). The image shows the change between the level of ozone in March 1993—a particularly bad year—and the average March level between 1979 and 1990. At midlatitudes, ozone levels (blue areas) are between 10 and 15 percent below the previous average, and nearer the pole they are as much as 20 percent below normal (purple). The red band over the Tropics shows a slight increase. The small black circle at the North Pole represents polar night, where no measurements are made.

Ozone is vital because it is the only component of the atmosphere that absorbs damaging ultraviolet radiation (UV-B) from the sun. The depletion of this protective layer, even by small amounts, may therefore have dire consequences for many organisms, including ourselves. Ozone, a blue-tinged gas that is a form of oxygen with three atoms instead of the usual two, is easily broken down by the chlorofluorocarbons and other pollutants that humans have dumped into the atmosphere. Despite international efforts to phase out the manufacture of the most destructive chemicals by the end of this century, some of those already released will persist in the stratosphere for many decades, eating away the ozone layer faster than it can be naturally replenished.

Quantifying the rise in UV-B radiation that accompanies the loss of ozone is complex, due to variable cloud cover and a host of other factors, but even a small loss of ozone can have large effects. One United Nations report calculated that even a one percent loss of ozone results in an extra 50,000 skin cancers and 100,000 cataracts worldwide.

A recent study of UV-B levels conducted by James B. Kerr and C. Thomas McElroy, of Environment Canada in Downsview, Ontario, gives some idea of how much more ultraviolet radiation is reaching the earth's surface. Their measurements, taken from the Toronto area (the same latitude where Andrew Blaustein conducted his field experiments on amphibian eggs), showed what a small change in ozone can mean. Between the winter of 1989–90 and the winter of 1992–93, ozone in the stratosphere dropped by 11 percent, but the amount of UV-B radiation reaching the ground climbed by 90 percent. Between the summer months for roughly the same period, ozone loss was 7.4 percent, while UV-B radiation increased by 30 percent. These increases may seem large, but because the ozone layer is so effective at blocking UV-B radiation, a doubling of the low natural levels still represents a relatively small exposure.—*R. A.*



NASA

Rob Simpson

What Are Squirrels Hiding?

Their half-eaten acorns are clues to a complex relationship with oaks

by Michael Steele and Peter Smallwood

Naturalists and casual observers alike have been struck by the special relationship between squirrels and acorns. As ecologists, though, we cannot observe these energetic mammals scurrying up and down oak trees and eating and burying acorns without wondering about their complex relationship with the trees. Are squirrels dispersers and planters of oak forests or pesky seed predators? The answer is not a simple one. Gray squirrels may devour many acorns, but by storing and failing to recover up to 74 percent of them (as they do when seeds are abundant), these arboreal rodents can also aid regeneration and dispersal of the oaks.

Their destructive powers are well documented. According to one 1908 report, squirrels destroyed tens of thousands of fallen acorns from an oak stand on the University of Indiana campus. A professor there estimated that each of the large white oaks had produced between two and eight thousand acorns, but within weeks of seed maturity hardly an acorn could be found among the fallen leaves.

Deer, turkeys, wild pigs, and bears also feed heavily on acorns, but do not store them, and are therefore of no benefit to the trees. Flying squirrels, chipmunks, and mice are also unlikely to promote tree dispersal, as they often store seeds in tree cavities and underground burrows. Only tree squirrels—whose behavior of caching below the leaf litter often promotes successful germination of acorns—and perhaps blue jays, important long-distance dispersers (see *Natural History,* October 1986), seem to help oaks spread and reproduce.

Early in our study, we observed one particularly puzzling behavior pattern. Squirrels would pry off the caps of acorns, bite through the shells to get at the nutritious inner kernels, and then discard them half eaten. Moments later, they would seize another acorn and repeat the routine. The ground under the towering oaks was littered with thousands of half-eaten acorns, each one bitten only from the top. Why would any animal waste so much time and energy and risk exposure to such predators as red-tailed hawks only to leave a large part of each acorn uneaten?

Gray squirrels are generally opportunistic in their feeding habits, but at other times they are picky. They often eat a variety of budding leaves, flowers, and spring twigs, and even the pupae of giant silk

After sprouting from acorns, red oak seedlings produce their first leaves, above. Acorns of red oaks are more often cached by squirrels, while those of white oaks are immediately eaten. Right: Before caching it for use in winter, a gray squirrel nips an acorn's tip, killing the oak embryo so the seed cannot sprout.

E. R. Degginger; Bruce Coleman, Inc.

An acorn weevil feeds on oak seeds, below. Female weevils may deposit their eggs in them, and squirrels will frequently eat such infested acorns, larvae and all. Right: Two young squirrels venture from their natal nest in the spring or early summer. Within days they will be weaned and left by their mother to forage for themselves.

Mark Moffett; Minden Pictures

Rob Simpson

moths, carrion, a bird's egg or two—and, rarely, nestling chicks. During the autumn and winter months, however, their main diet consists of nuts and seeds, and at this time squirrels readily distinguish between various species, and even parts, of acorns. Active throughout the year, the squirrels store large quantities of seeds and nuts to see them through the winter. These caches usually include acorns of some of the thirty-two oak species that grow in the squirrel's range in eastern North America.

An oak seed, or acorn (really a fruit), consists of an outer shell enclosing two young, energy-rich seed leaves (or cotyledons) that meet to surround a tiny embryo at the apex, or tip. To a squirrel, the acorn is a package of energy (between five and twenty kilocalories) that can be easily opened and eaten in less than half the time needed for other, harder nuts or stored for use up to ten months later.

Not all acorns are the same. The two major groups of oaks—red and white—have seeds that differ generally in chemical makeup. Red oak acorns are rich in fats (18 to 25 percent of dry weight) but are laced with 6 to 10 percent tannins (the bitter-tasting, water-soluble compounds used to tan hides). White oak acorns are less fatty (5 to 10 percent) and lower in tannins (less than 2 percent). The two groups of trees also differ in when they germinate. Red oak acorns lie dormant in winter and sprout in spring; white oak seeds usually sprout soon after falling to the ground in autumn.

We knew that more fat enhances the seeds' energy value, but we also suspected that high tannin levels make them less palatable and digestible to squirrels. Tannin in oak leaves repels many insects, and some trees may even increase their tannin concentrations as a natural pesticide. Do these chemicals also repel squirrels or do the squirrels rely on them to protect their own acorn caches from insects and other pathogens? How do tannins and other acorn chemicals influence the squirrels' feeding and caching decisions? And do these behaviors, in turn, affect the distribution of oaks? These were but a few of the questions we sought to answer with a series of field experiments.

In 1980, zoologist Alan R. Lewis studied the dietary preferences of squirrels in the winter by identifying the remains of acorns left behind after squirrels had eaten from their caches. Lewis demonstrated that squirrel preferences depend not only on the energy content of the acorns but also on their relative abundance. Sometimes as many as six species of oaks grow within the range of a single gray squirrel. Lewis found that when faced with these choices, the squirrels ate more fatty acorns, except when the lower-energy acorns were more numerous. Other researchers have shown that squirrels are generally efficient in their feeding habits, expending the least amount of energy to obtain the most nutritious foods (see *Natural History,* October 1989). Ecologist Christopher C. Smith, of Kansas State University, and others had shown that given a choice, squirrels preferred to take mostly the high-fat red oak acorns.

To further analyze the squirrels' preferences, Peter Smallwood and David Peters, of Ohio State University, created "artificial acorns" with measured chemical additives. After shelling and processing white oak acorns into a dough, they added various levels of tannin and fat to simulate those in real acorns. The squirrels consistently chose to eat the acorns with lower tannin levels, particularly in autumn—even those acorns with low fat content.

These results seemed to contradict such earlier studies of squirrels' food preferences as Smith's. After wrestling with this inconsistency, however, Smallwood and

Peters realized that squirrels may exhibit different preferences for caching and eating. Perhaps squirrels use one kind of acorn for immediate consumption and another for storing. When white oak acorns germinate in the fall, they concentrate much of their nutrients in a taproot, which squirrels find unpalatable. We wondered whether squirrels might eat white oak acorns immediately because their early germination renders them unsuitable for caching, and store the red oak acorns, which germinate later, for consumption in winter and spring.

To test this idea, we presented gray squirrels in Ohio and Pennsylvania parks and campuses with both red oak and white oak acorns. In each of more than 1,200 feeding trials, we recorded whether the acorn was eaten or stored, the distance it was dispersed, and the amount of time the animal took to eat or bury the acorn. Unambiguously, squirrels cached more red oak acorns (60 percent) and consistently ate those of the white oaks (more than 85 percent).

In a second group of experiments we attempted to determine the squirrel's role in dispersing trees—this time in mature oak forests in Pennsylvania's Pocono region. But we often failed to find the buried acorns, even after watching a squirrel only ten feet away shove a nut into a shallow hole, cover it, and brush debris over the top. Clearly, we needed a more sophisticated approach. Following the lead of botanist Victoria Sork, we tagged thousands of red and white acorns with small metal labels and, after the animals dispersed the seeds, used metal detectors to recover them. Again, the results were clear. Squirrels either ate white oak acorns on the spot or carried them only short distances before eating them. Red oak acorns were generally carried farther away and cached intact.

Other factors besides germination schedules and seed chemistry affect the seeds' perishability. Might squirrels also respond to these in deciding whether to cache? Many acorns become infested with insect larvae, particularly weevils of the genus *Curculio*. During spring, females of several species of these beetles bore into acorns to deposit their eggs. By early fall, the maggot-sized larvae have often destroyed more than 60 percent of the crop of single trees. Would squirrels avoid wormy acorns as less suitable for storing?

We identified batches of infested acorns

Preparing to cache an acorn, a gray squirrel excavates a hole in the soil. Often squirrels go through the motions of burying acorns, only to store the seeds elsewhere.
E. A. Janes; NHPA

by having them X-rayed at a local hospital, then offered them to the squirrels. Consistently, they selected noninfested seeds for caching, but opened and consumed the infested ones, eating the weevils as well. In nearly 300 tests, the squirrels readily ate the high-protein larvae.

Sometimes squirrels kill the early-sprouting white oak acorns by excising the seed embryos just before burying them, as John Fox reported in 1982. If an acorn germinates before the squirrel can recover it, up to half its stored energy goes to the seedling rather than the squirrel. A few quick scrapes of the squirrel's incisors across the bottom of the acorn kills the embryo and preserves the seed's nutrients intact.

While this notching behavior underscores the importance of seed perishability, it does not explain the habit of biting and discarding acorns that so intrigued us at the beginning of our study. Those squirrels ate only from the acorn's top half—the end farthest from the embryo. And the acorns were of red oaks, not white. As we moved our research from parks and campuses to rural woodlands, from the scrub-oak forests of the southeastern coastal plain to the oak-hickory forests of the Middle Atlantic States, we saw the same pattern. Squirrels bit off the tops of acorns of at least seven red oak species. We also found that blue jays and common grackles did the same. Squirrels, jays, and grackles each employed a different technique to open an acorn, but all consumed only 30 to 60 percent of the kernel—and always from the top of the seed. Later we discovered that weevil larvae were found in the top of the acorn two to three times more often than in the bottom.

Our first guess, that higher levels of noxious tannins are located near the bottom of the acorn, where the embryo is located, was borne out by chemical tests. But we also found, in more than seventy-five trials, that squirrels frequently cached partly eaten seeds, which raises the possibility that the acorns may have become adapted to withstand such attacks. Because their embryos were not destroyed, these seeds germinated about as often as undamaged ones. Perhaps for the oak, the half-palatable acorn is an effective strategy for survival. Maybe acorns benefit from being chosen by squirrels for burial and dispersal, as long as they are not totally destroyed.

We still wondered what factors other than tannin content influenced the squirrels' choices. What about the acorn's shape, for instance, or the toughness of its shell? In pursuit of these questions, we offered gray squirrels their choice of whole acorns, shelled acorns, and shelled acorns in which the bottom and top ends were carved to resemble the opposite ends. Squirrels ate just the top portion of both whole and shelled seeds, indicating that the shell was not the determining factor. But when we presented squirrels with carved seeds, we found that they were fooled into eating in reverse, feeding only on the disguised bottom half. Next we presented squirrels with artificial acorns that contained varying amounts of tannin. Consistently, when given those seeds with the highest tannin concentration, squirrels ate from the top half but consumed only a small amount.

Ecologist Joseph Grinnell, in a 1936 paper, pondered how oaks could colonize hilltops, since acorns are too heavy for wind dispersal and do not roll uphill. He concluded that animals must carry them to such sites. Although we are only just begining to grasp some of the complexities of the squirrels' relationship with oak forests, we agree with Grinnell's early assessment. By dispersing red oak acorns more often and farther than white oak acorns, by excising the embryo of white oak acorns and storing primarily sound acorns, we suspect that gray squirrels can strongly influence the distribution and range of various oak species. Indeed, evidence is accumulating that along with jays, squirrels are crucial in regenerating second-growth oak forests and may even have been responsible for spreading the vast stands of oak throughout North America after the last retreat of the glaciers 10,000 years ago. □

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"Empires Beyond the Great Wall," an exhibition documenting 3,500 years of the history and culture of steppe empires, will be at the American Museum of Natural History through Sunday, November 27.

All the Khan's Horses

With fresh mounts in reserve, Genghis Khan's warriors could outlast any enemy

by Morris Rossabi

In August 1227, a somber funeral procession—escorting the body of perhaps the most renowned conqueror in world history—made its way toward the Burkhan Khaldun (Buddha Cliff) in northeastern Mongolia. Commanding a military force that never amounted to more than 200,000 troops, this Mongol ruler had united the disparate, nomadic Mongol tribes and initiated the conquest of territory stretching from Korea to Hungary and from Russia to modern Vietnam and Syria. His title was Genghis Khan, "Khan of All Between the Oceans."

Genghis Khan and his descendants could not have conquered and ruled the largest land empire in world history without their diminutive but extremely hardy steeds. In some respects, these Mongolian ponies resembled what is now known as Przewalski's horse (see page 54). Mongols held these horses in highest regard and accorded them great spiritual significance. Before setting forth on military expeditions, for example, commanders would scatter mare's milk on the earth to insure victory. In shamanic rituals, horses were sacrificed to provide "transport" to heaven.

The Mongols prized their horses primarily for the advantages they offered in warfare. In combat, the horses were fast and flexible, and Genghis Khan was the first leader to capitalize fully on these strengths. After hit-and-run raids, for example, his horsemen could race back and quickly disappear into their native steppes. Enemy armies from the sedentary agricultural societies to the south frequently had to abandon their pursuit because they were not accustomed to long rides on horseback and thus could not move as quickly. Nor could these farmer-soldiers leave their fields for extended periods to chase after the Mongols.

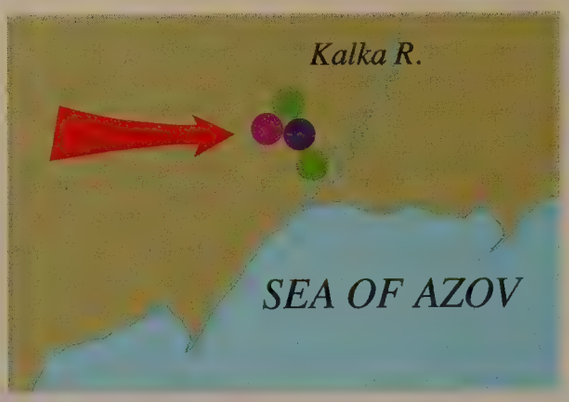
The Mongols had developed a composite bow made out of sinew and horn and were skilled at shooting it while riding, which gave them the upper hand against ordinary foot soldiers. With a range of more than 350 yards, the bow was superior to the contemporaneous English longbow, whose range was only 250 yards. A wood-and-leather saddle, which was rubbed with sheep's fat to prevent cracking and shrinkage, allowed the horses to bear the weight of their riders for long periods and also permitted the riders to retain a firm seat. Their saddlebags contained cooking pots, dried meat, yogurt, water bottles, and other essentials for lengthy expeditions. Finally, a sturdy stirrup enabled horsemen to be steadier and thus more accurate in shooting when mounted. A Chinese chronicler recognized the horse's value to the Mongols, observing that "by nature they [the Mongols] are good at riding and shooting. Therefore they took possession of the world through this advantage of bow and horse."

Genghis Khan understood the importance of horses and insisted that his troops be solicitous of their steeds. A cavalryman normally had three or four, so that each was, at one time or another, given a respite from bearing the weight of the rider during a lengthy journey. Before combat, leather coverings were placed on the head of each horse and its body was covered with armor. After combat, Mongol horses could traverse the most rugged terrain and survive on little fodder.

According to Marco Polo, the horse also

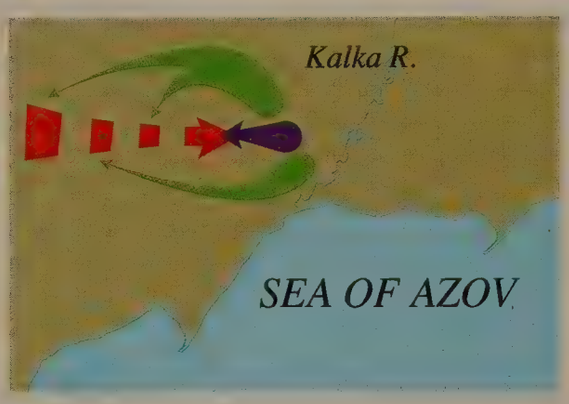
Mongol cavalrymen engage the enemy, facing page, in an illustration from an early-fourteenth-century manuscript by Rashid al-Din, a Persian-Jewish historian and an important minister at the Mongol court in Tabriz.
Wan-Go H. C. Weng; Bibliothèque Nationale

For almost ten days before the Kalka River battle on May 31, 1223, more than 20,000 invading Mongols (colored dots) feigned retreat before a Russian force (red arrow) of 80,000 men. At the Kalka River, the Mongols finally re-formed their ranks.



After pursuing the Mongols for days, the exhausted Russian troops were spread out along a twenty-mile line. The Mongols charged, with 5,000 mounted archers (violet arrows) in the lead.

Once the leading Russian detachments were separated from their support columns and thrown into disarray, 5,000 Mongol heavy cavalry troops (dark blue) engaged them in close combat. Ten thousand light cavalry troops (light green) followed the retreating Russians, capturing or slaughtering most of them.



provided sustenance to its rider on long trips during which all the food had been consumed. On such occasions, the rider would cut the horse's veins and drink the blood that spurted forth. Marco Polo reported, perhaps with some exaggeration, that a horseman could, by nourishing himself on his horse's blood, "ride quite ten days' marches without eating any cooked food and without lighting a fire." And because its milk offered additional sustenance during extended military campaigns, a cavalryman usually preferred a mare as a mount. The milk was often fermented to produce kumiss, or *araq*, a potent alcoholic drink liberally consumed by the Mongols. In short, as one commander stated, "If the horse dies, I die; if it lives, I survive."

Mobility and surprise characterized the military expeditions led by Genghis Khan and his commanders, and the horse was crucial for such tactics and strategy. Horses could, without exaggeration, be referred to as the intercontinental ballistic missiles of the thirteenth century. The battle of the Kalka River, now renamed the Kalmyus River, in southern Russia is a good example of the kind

Overleaf: The painter of this somewhat inaccurate depiction of a Mongol bridling a horse was probably a Persian city dweller eager to ingratiate himself with his Mongol patrons.
Topkapi Palace Museum, Istanbul

An illustration from History of the Moghuls, *a seventeenth-century Indian text, depicts Genghis Khan's army in battle against the Jurchen rulers of China in about 1214. The Mongols' horses appear to be well protected by leather and armor.*
Gulestan Palace Library, Tehran; Werner Forman Archive, Art Resource

A Horse of a Different Chromosome?

by Oliver A. Ryder

Although Genghi Khan's armies probably never numbered more than 200,000 troops, they may have had as many as 800,000 horses. Thirteenth-century sources, including *The Secret History of the Mongols*, give a tantalizing account of the training of Mongol horses. Captured in the wild and broken-in during the first two years of their lives, the young horses were then allowed to graze for three years.

Dominique Braud; Dembinsky Photo Assoc.

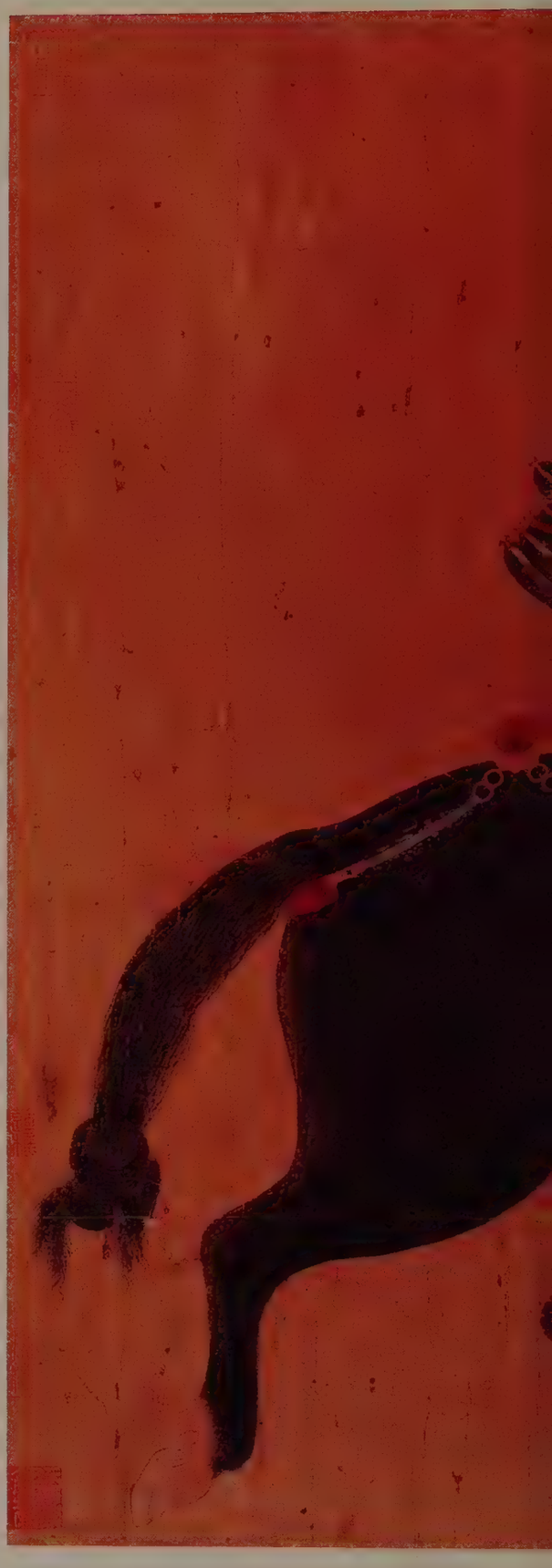
At the age of five they were once again ridden and prepared for combat. The Mongols depended on their horses so much, and gathered so many of them, that John of Plano Carpini, a papal emissary to the Mongol court from 1246 to 1247, noted with amazement that "they have such a number of horses and mares that I do not believe there are so many in all the rest of the world." What kind of horses were they?

A number of Mongol scholars, including historians James Chambers and Charles R. Bawden, have noted that the horses used by Genghis Khan and his descendants resembled Przewalski's horse, the species of wild horse that formerly inhabited the Gobi Desert and the steppes of Mongolia.

Przewalski's horse is named for Russian explorer and naturalist N. M. Przhevalsky, who first saw herds of the yellowish brown species in the central Asian steppes in about 1876. Both Przewalski's and the domestic horse are descended from the same lineage in the family Equidae, but Przewalski's horses differ from domestic horses morphologically, behaviorally, and genetically. All domestic breeds have 64 chromosomes, whereas Przewalski's have 66. (First-generation hybrids have 65 chromosomes and may interbreed with either domestic or Przewalski's horses.) Przewalski's horses have an erect, dark brown mane, no forelock, and white noses. Their coat has a distinctive dun color with a yellowish tinge on the back that becomes lighter toward the flanks and almost white under the belly. Their appearance is accentuated by bulky heads and, especially in stallions, stocky, well-muscled necks. Although their behavior has never been observed in wild populations, studies of herds kept in large enclosures and reserves suggest that, like feral domestic horses, stallions defend harems of mares from male competitors.

Przewalski's horses became extinct in the wild when the last survivors disappeared from the Dzungarian gobi of Mongolia in 1970, but were saved from total extinction by the existence of captive populations bred in zoos. Plans are now under way to return the only true wild horse to its ancient homelands in Mongolia, China, and adjacent regions of Russia. Experimental studies of herds of zoo-raised Przewalski's horses placed in new prairie and semidesert steppe environments suggest that adaptation to the wild environment can be rapidly accomplished. Perhaps one day they will repopulate their homelands and again roam freely in the wild.

Oliver A. Ryder holds the Kelberg Genetics Chair at the Zoological Society of San Diego's Center for Reproduction of Endangered Species. He has published extensively on the genetics of Przewalski's horses and other endangered species, and is particularly interested in the conservation of Asian arid steppe ecosystems and their wildlife.



of campaign Genghis Khan waged to gain territory and of the key role of horses.

After his relatively easy conquest of Central Asia from 1219 to 1220, Genghis Khan had dispatched about 30,000 troops led by Jebe and Sübedei, two of his ablest commanders, to conduct an exploratory foray to the west. After several skirmishes in Persia, the advance forces reached southern Russia. In an initial engagement, the Mongols, appearing to retreat, lured a much larger detachment of Georgian cavalry on a chase. When the Mongols sensed

In a fifteenth-century Ming Dynasty painting, a Mongol archer rides a horse equipped with sturdy stirrups and an elaborate saddle. An archer could shoot arrows accurately while riding at full tilt across the steppe.
Victoria and Albert Museum

that the Georgian horses were exhausted, they headed to where they kept reserve horses, quickly switched to them, and charged at the bedraggled, spread-out Georgians. Archers, who had been hiding with the reserve horses, backed up the cavalry—with a barrage of arrows as they routed the Georgians.

Continuing their exploration, the Mongol detachment crossed the Caucasus Mountains, a daunting expedition during which many men and horses perished. They wound up just north of the Black Sea on the southern Russian steppes, which offered rich pasturelands for their horses. After a brief respite, they first attacked Astrakhan to the east and then raided sites along the Dniester and Dnieper Rivers, inciting Russian retaliation in May of 1223 under Mstislav the Daring, who had a force of 80,000 men. Jebe and Sübedei commanded no more than 20,000 troops and were outnumbered by a ratio of four to one.

Knowing that an immediate, direct clash could be disastrous, the Mongols again used their tactic of feigned withdrawal. They

A late-fourteenth-century Persian painter depicted Mongols on a hunt. Falcons and dogs typically accompanied the horsemen.
The Topkapi Palace Museum, Istanbul

Opposite page: A seventeenth-century Indian miniature shows Genghis Khan praying to Tenggeri, the sky god, who, according to legend, entrusted him with the mission of uniting the world under Mongol control. The Mongol ruler is portrayed with Persian features and wearing Persian clothing.
Werner Forman Archive; Art Resource

retreated for more than a week, because they wanted to be certain that the opposing army continued to pursue them but was spaced out over a considerable distance. At the Kalka River, the Mongols finally took a stand, swerving around and positioning themselves in battle formation, with archers mounted on horses in the front.

The Mongols' retreat seems to have lulled the Russians into believing that the invaders from the East were in disarray. Without waiting for the remainder of his army to catch up and without devising a unified attack, Mstislav the Daring ordered the advance troops to charge immediately. This decision proved to be calamitous. Mongol archers on their well-trained steeds crisscrossed the Russian route of attack, shooting their arrows with great precision. The Russian line of troops was disrupted, and the soldiers scattered.

After their attack, the archers turned the battlefield over to the Mongol heavy cavalry, which pummeled the already battered, disunited, and scattered Russians. Wearing an iron helmet, a shirt of raw silk, a coat of mail, and a cuirass, each Mongol in the heavy cavalry carried with him two bows, a dagger, a battle-ax, a twelve-foot lance, and a lasso as his principal weapons. Using lances, the detachment of heavy cavalry rapidly attacked and overwhelmed the Russian vanguard, which had been cut off from the rest of their forces in the very beginning of the battle.

Rejoined by the mounted archers, the combined Mongol force mowed down the straggling remnants of the Russian forces. Without an escape route, most were killed, and the rest, including Mstislav the Daring, were captured. Rather than shed the blood of rival princes—one of Genghis Khan's commands—Jebe and Sübedei ordered the unfortunate commander and two other princes stretched out under boards and slowly suffocated as Mongols stood or sat upon the boards during the victory banquet.

The battle at the Kalka River resembled, with some slight deviations, the general plan of most of Genghis Khan's campaigns. In less than two decades, Genghis Khan had, with the support of powerful cavalry, laid the foundations for an empire that was to control and govern much of Asia in the thirteenth and fourteenth centuries. He died on a campaign in Central Asia, and his underlings decided to return his corpse to his native land. Any unfortunate individual who happened to encounter the funeral cortege was immediately killed because the Mongols wished to conceal the precise location of the burial site. At least forty horses were reputedly sacrificed at Genghis Khan's tomb; his trusted steeds would be as important to him in the afterlife as they had been during his lifetime. □

Cardon and the Night Visitors

Bats pollinate a giant cactus—and may even determine its sex

by Theodore H. Fleming

Along a narrow belt in Mexico's western Sonoran Desert grows the cardon, the world's largest cactus. Widespread in Baja California and coastal Sonora, the cardon resembles the much more familiar saguaro because of its single trunk and multiple branches, but it is more massive. Like saguaros, young cardons grow slowly, most plants taking at least fifty years to attain sexual maturity. Large individuals may live well over a century and reach a maximum height of about sixty feet.

Like the saguaro and organ pipe cactuses with which they share their habitat, cardons provide food and shelter for many creatures. Elf owls make their homes in cactus cavities excavated by woodpeckers, as do violet-green swallows, ash-throated flycatchers, and even big brown bats. Ospreys and red-tailed hawks sometimes build their nest platforms on the cardon's highest branches. Yet, familiar as the cardon is to naturalists, no one realized that it also has the most enigmatic breed-

Left: Symmetrically patterned spines crown a cardon cactus, seen from above, in Mexico's Sonoran Desert. In Baja California Sur, above, sunrise over the Sierra Giganta illuminates a mixed forest of cardon cactuses and palos blancos, *or white-barked trees.*

Both photos by Jack W. Dykinga

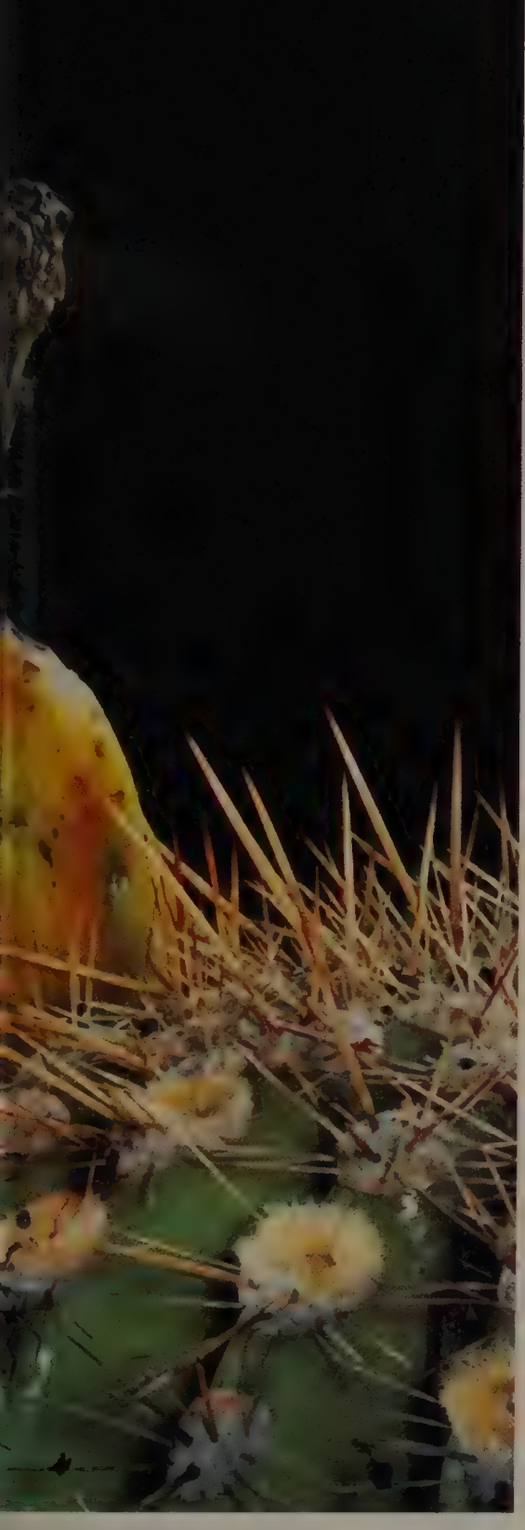
ing system of any cactus—a puzzle that Sandrine Maurice, of the University of Paris, James Hamrick, of the University of Georgia, and I have been piecing together for the last few years.

Like most flowering plants, cactuses are usually hermaphroditic; that is, their flowers have both male and female organs producing pollen and ovules. Because their flowers appear to have fully functional anthers and ovaries, botanists assumed that the cardon, too, was a hermaphrodite. For a long time, they also assumed that the flowers were pollinated by wind, insects, or birds. But telltale signs pointed to another kind of pollinator. Cardon flowers are large (most wind-pollinated flowers are small) and white, so they are visible at night. In addition, they open at sundown (when birds aren't active) and produce large amounts of pollen and nectar. All these traits point to pollination by bats. Several years ago, Merlin Tuttle, of Bat Conservation International, and I began to investigate that possibility.

Bats pollinate a number of tropical trees, including the commercially valuable balsa, the fiber-producing kapok, and the durian, the source of a major fruit crop in Southeast Asia. Century plants, the basis of mescal and tequila, are also pollinated by bats. Since the 1890s, we have known that some specialized tropical bats, especially those living in drier areas, pollinate the flowers of certain shrubs, trees, and vines—and do so exclusively at night.

Cardons, we soon found, are visited by birds and by the occasional moth, but they are primarily pollinated by lesser long-nosed bats, a species that migrates from central Mexico to the Sonoran Desert each spring. Weighing just under one ounce, these mammals have a wingspan of about thirteen inches. We have radio-tracked their flights and found that the bats will fly at least fifteen to twenty miles, and possibly as far as fifty miles, from their roosts to feed on the nectar and pollen of various cactuses, including the saguaro and the organ pipe. Even more dependent on plants for food than are hummingbirds (which often supplement their diet of flower nectar with insects), these bats use the amino acids in pollen to make protein.

Merlin D. Tuttle, Bat Conservation International; Photo Researchers, Inc.



Lesser long-nosed bats, the principal pollinators of cardon cactuses, zero in on fruits, left, and flowers, below, during nocturnal forays of fifteen miles or more. The distance between the bats' roosts and the plants may influence the proportion of male, female, and hermaphroditic plants in the cactus populations.

Merlin D. Tuttle; Bat Conservation International

Foraging for about four hours each night, they carry pollen from plant to plant. When fruits mature, the bats also eat the pulp, dispersing seeds in their excreta.

Each spring, after mating with males on their central Mexican wintering grounds, pregnant females fly north, following the blooming schedules of columnar cactuses. Most of the males remain behind. The females assemble in maternity roosts in caves or abandoned mines, each giving birth to a single young in May. Such roosts may contain from a few thousand to 100,000 female bats.

When we began our study of the cardon at Bahia Kino, on the Gulf of California, we didn't realize that it had a rare and complicated breeding biology. We discovered this complexity by accident while trying to determine the importance of bats as cactus pollinators. The ephemeral cardon flowers bloom for only one night, opening at sunset and closing before noon the next day. In our earliest experiments, we placed bridal-veil netting over the flowers to separate the effects of bats and moths from those of birds and diurnal insects. We covered some flowers only during the day and others only at night, then recorded the percentage of flowers that developed into mature fruit. Our control group consisted of flowers that were not covered with netting and were visited by both nocturnal and diurnal pollinators.

We were disappointed to find that very few of our flowers (whether covered or uncovered) produced any fruit, and we thought the experiment had been a failure. When we examined many of the flowers more carefully, however, we were surprised to discover that all of the flowers on some plants produced pollen but lacked ovules; these plants were males. Other plants, we found, produced flowers that lacked pollen but *did* have ovules; these were females. Still other plants—the hermaphrodites—produced flowers with both pollen and ovules. No wonder most of the cardons in our experiment failed to produce fruit; we had inadvertently used mostly male plants! Once we recognized their gender system, we performed the experiments again and eventually demonstrated that because bats carry much larger amounts of pollen than do insects or birds, they were the superior pollinators.

The very presence of male and female plants in populations that also contain hermaphrodites raised an interesting evolutionary question. How can a male or female plant, which must somehow connect genetically with another, perhaps distant, plant of the opposite gender, reproduce as successfully as a hermaphrodite, which has flowers of both sexes on each plant? The hermaphrodite, with two ways of perpetuating itself (through pollen and seeds), would appear to have competitive superiority. Furthermore, hermaphroditic cardons are "self-compatible," that is, their pollen can successfully fertilize ovules on the same plant, or even within the same flower. Hence they sometimes produce fruit and offspring without the aid of bird, bee, or bat. With such advantages, why haven't the hermaphrodites simply overwhelmed the males and females and pushed them out of the population?

A cardon cactus, left, blooms in the Sonoran coastal area near Puerto Lobos. The large, white flowers that open at sundown and produce large quantities of nectar and pollen are signs of coevolution with bat pollinators. The cardon, which grows in the Baja California desert, below, is the world's largest species of cactus. Some individuals may be sixty feet tall and live more than a century.
Jeff Foott; DRK Photo

We reasoned that, to have remained in the population, the single-sex plants must have had a compensatory feature that allowed them to persist genetically. We hypothesized that the males were producing more pollen and the females more fruit and seeds than their hermaphroditic counterparts. To test this idea, we measured pollen and/or seed production in all sexes and found that male and female plants indeed outproduced hermaphrodites in both respects. Each year, males produced about 60 percent more flowers and pollen, and females produced about 60 percent more seeds than the average hermaphrodite. Given enough visits by bats and other pollinators, males might be able to fertilize enough ovules and females to maintain their presence in a cactus population.

Another question arose after we completed our pollination studies at Bahia Kino and had gone on to survey the proportions of sexes throughout the plant's range in Sonora and Baja California. The distribution of the sexes varied significantly from place to place. Some cactus stands contained all three sex classes, while others included only females and hermaphrodites. No males were present in the southern third of the plant's range in Sonora or in the northern quarter of the range in Baja California. Where males were missing, hermaphrodites outnumbered females by about two to one.

What factor or factors might produce this geographic pattern? We wondered if climate might be the reason that no males lived in extreme parts of the species' range, but we soon found male cactuses growing in a wide variety of climatic conditions.

Next, we questioned whether male plants, which, along with females, we presumed to be mutants of hermaphroditic ancestry, hadn't had time to spread throughout the cardon's range. Genetic tests, however, revealed that these cactuses, although spread over a wide geographic area, constantly exchange genetic material. We believe that the long-distance flights of the bat pollinators have kept local populations from becoming isolated and inbred.

Finally, we explored whether the clumped distribution of male plants might be correlated with the ranges of bats. When we mapped the locations of known maternity roosts against the distribution of male cardons, we found a close fit. With one distant exception, all of the known maternity roosts in Sonora are in the northern half of the cardon's range, while all of the known roosts in Baja are in the southern two-thirds of its range. Male plants are found only within those two areas that are within about a fifty-mile radius of known bat roosts.

To make sure it was the distribution of bats rather than of some other pollinator that influenced the distribution of the cardons' sexes, we observed the behavior of cardon-visiting animals at four sites with

males and four that lacked males. The most frequent avian visitors to cardon flowers during the day were gila woodpeckers, but these and other birds visited only about 13 percent of the flowers, usually less than once per hour. In contrast, bats visited about 90 percent of the flowers, but sites containing males differed in the time of arrival of bats. Bats began feeding before 9:00 P.M. at sites with male cactuses, but arrived later—after 11:00 P.M.—at places that lacked males.

We know from our radio-tracking studies that the time that bats arrive in an area depends on its distance from a roost. We also know from our observations at Bahia Kino that the later bats arrive in an area, the fewer visits they make to each cardon flower. Thus, flowers farther from bat roosts probably receive fewer visits than do those closer to the roosts.

Why do male cactuses drop in and out of populations while females do not? We don't yet understand the cardon's reproductive genetics, but we think males may be eliminated in some local populations because they are in strong competition with hermaphrodites. Hermaphroditic plants, by fertilizing their own ovules with or without the aid of pollinators, significantly reduce the number of ovules available to a male plant's pollen. Thus, despite producing more pollen than hermaphrodites, a male's pollen can only reach the ovules of females and hermaphrodites when pollinators are abundant. Female plants are totally dependent on animal pollinators. But when pollinators are relatively scarce, females still produce as many seeds per season as hermaphrodites do. Hence, they can persist in locations where males cannot.

The lives of this desert bat and desert cactus appear to have coevolved. Cardon plants are an important source of nectar, pollen, and fruit pulp for the bat. The bat, in turn, helps determine the reproductive success of individual plants through pollination and seed dispersal. By carrying pollen or seeds long distances, it can also influence the genetic and sexual composition of cardon populations. □

Seeking nectar, a lesser long-nosed bat pokes its entire head into a cardon flower.
Merlin D. Tuttle, Bat Conservation International; Photo Researchers, Inc.

At the American Museum of Natural History

125 Years of Discovery

As part of the Museum's 125th anniversary, an exhibition of selected artifacts, specimens, and memorabilia from the Museum's collections will open on Friday, October 14, in the Birds of the World Hall. The displays will include a mounted lion purchased in 1869 from the collections of Paris taxidermist Edouard Verreaux; a specimen of the now-extinct great auk; the complete skeleton of *Oxyaena,* an early carnivorous mammal collected in Wyoming in the 1890s; a painting of this animal as it might have appeared in life, by Charles R. Knight; two shadow puppets acquired in the South Pacific by anthropologist Margaret Mead in the 1930s; dinosaur eggs discovered in Mongolia by paleontologist Walter Granger during the Museum's Central Asiatic Expeditions in the 1920s; and the recent discovery by Museum scientists in Mongolia of the remains of the dinosaurlike *Mononykus,* a possible link between birds and theropod dinosaurs.

Also on October 14, a photo exhibition, "People and Places," will open in the Akeley Gallery. Taken on Museum expeditions, the photographs range from those by Carl Lumholtz in Mexico and Adolph Bandelier in Peru and Bolivia in the 1890s to more recent ones by Stanley A. Freed in India in the 1950s and 1970s and Ross McPhee in Cuba and Vietnam in the 1990s.

Margaret Mead Film and Video Festival

Shamanism and familial relationships will be among the major themes of the sixty-two films presented at the 1994 Margaret Mead Film and Video Festival. The Festival will open on Wednesday, October 12, and run through Tuesday, October 18. This year's retrospective celebrates the works of Richard Gordon and Carma Hinton, whose films on China have appeared at the Festival since its inception in 1976. One of the opening-night films will be *Fearless—The Hunterwali Story,* featuring Nadia, India's legendary stunt actress of the 1930s and 1940s. Director Riyad Vinci Wadia will introduce the film and answer questions afterward.

Same-day tickets may be purchased after 5:00 P.M. on weekdays or 10:30 A.M. on weekends for $8 ($7 for members and students with I.D.). A Festival pass for $44 ($40 for members and students with I.D.) and daily tickets can be prepurchased with MasterCard or VISA by calling (212) 769-5310. Seating is limited. For a complete schedule, call (212) 769-5305.

Okavango: Africa's Last Eden

Photographer Frans Lanting spent two years photographing the diverse flora and fauna of southern Africa's Okavango Delta, a project culminating in his book

A photograph from the memorabilia exhibit shows a messenger from the Museum's Education Department delivering taxidermy specimens to a New York City public school, June 1932.
AMNH

THE INKA EMPIRE AND ITS ANDEAN ORIGINS

Trace the story of the Andean peoples with this beautifully produced new appraisal of the ancient Inka and the remarkable cultures that preceded them.

Written by Dr. Craig Morris, American Museum of Natural History Curator of Anthropology, and noted journalist Adrianna von Hagen, this comprehensive study describes their agricultural methods, social organizations, political structure, religious beliefs, ceremonial practices, technologies, and artistic expression. The text resonates with more than one hundred exquisite color photographs of objects from the Museum's rich collection of artifacts and offers compelling panoramas of the spectacular and diverse Andean landscape.

252 pages, 9 7/8" x 9 7/8", 200 illustrations, cloth

To order send check or money order for $50.00 including shipping and handling within the U.S. to Members' Choice, American Museum of Natural History, Central Park West at 79th Street, New York, NY 10024 or call toll-free 1-800-437-0033 for Mastercard and Visa orders.

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HOFSTRA UNIVERSITY

Museum anthropologist Adolph Bandelier, on the Henry Villard expedition to Peru and Bolivia, 1892.
AMNH

Okavango: Africa's Last Eden. On Thursday, October 6, he will give a slide-illustrated talk on this region, a wetland oasis of more than 8,500 square miles in Botswana's Kalahari Desert. The talk will begin at 7:00 P.M. in the Main Auditorium. Call (212) 769-5606 for information.

Jennie—A Tale of a Chimpanzee

As a columnist for *Natural History* in the 1980s, Douglas Preston explored the Museum's vaults, storage rooms, and archives, and wrote about his findings in *Dinosaurs in the Attic* (1986). The tragic tale of Meshie, a chimpanzee raised by a Museum curator, has become the basis of Preston's novel *Jennie,* which raises ethical questions about the use of primates for research, as well as attempts to raise chimps among humans. On Tuesday, October 11, at 7:00 P.M. in the Kaufmann Theater, Preston will show film footage of Meshie from the Museum's archives and talk about the case histories of other chimpanzees such as Lucy, Nim Chimpsky, Viki Hayes, and Washoe. For more information, call (212) 769-5606.

Hudson Valley Cruise

On Sunday, October 23, a high-speed catamaran will leave from Wall Street at noon and cruise as far as West Point, returning to New York by 4:00 P.M. Sidney Horenstein, coordinator of environmental public programs at the Museum, will point out aspects of geological interest along the way, and William Schuster, director of the Black Rock Forest Preserve, will talk about local plant life and the relationship of Black Rock to the rest of the Hudson Highlands. For ticket availability, call (212) 769-5606.

Yellowstone

The history, geology, and wildlife of Yellowstone National Park are the subjects of a new IMAX film. The Grand Teton Mountains, the Lower Falls of the Grand Canyon of Yellowstone, and the interior of a vent of Old Faithful will be among the places featured. Showtimes are 12:30, 2:30, and 4:30 P.M. *Africa: The Serengeti,* an IMAX film about the vast savanna ecosystem of Kenya and Tanzania, will be shown at 10:30 and 11:30 A.M., and at 1:30 and 3:30 P.M. daily. For information, call (212) 769-5650.

Dangerous Windows into the Earth

The hazards of earthquakes, from New York to California, will be the subject of four Tuesday-evening lectures. On October 11, Barbara Romanowicz, head of the Berkeley Seismic Station and professor of geology and geophysics at the University of California at Berkeley, will talk on what earthquakes tell us about the earth. On October 18, Allan G. Lindh, chief of the U. S. Geological Survey's seismology branch, will discuss the seismic activity of the San Andreas Fault system. On October 25, Klaus Jacob and Leonardo Doherty, scientists at Columbia University's Lamont-Doherty Earth Observatory, will evaluate the possibility of earthquakes in "stable" continental areas. Finally, on November 1, Lloyd Cluff, president of the Earthquake Engineering Research Institute, will discuss what we can do about earthquakes. Tickets for all four lectures are $25 ($20 for students). For a complete schedule of fall lectures, call (212) 769-5310.

Plants of the Wetlands

The plant diversity of lakeshores, floodplains, bogs, marshes, and seasides will be the subject of a five-part series by William Schiller, lecturer in botany in the Museum's Department of Education. The hour-and-a-half talks will be held in the Kaufmann Theater on consecutive Mondays at 2:30 P.M., starting on October 24, and on consecutive Thursdays at 7:00 P.M., starting October 20. Tickets for all five lectures are $40.

The Heritage of Genghis Khan

Adam T. Kessler, curator of "Empires Beyond the Great Wall," will lead a gallery tour of the exhibition and will discuss the artifacts on display and the steppe culture of the Mongol people. Tours cost $12 and will be given on Monday, October 3; Wednesday, October 5; and Friday, October 7, starting at 7:00 P.M. Call (212) 769-5310 for details.

These events take place at the American Museum of Natural History, Central Park West at 79th Street in New York City. The Kaufmann Theater is located in the Charles A. Dana Education Wing. The Museum has a pay-what-you-wish admission policy. For more information about the Museum, call (212) 769-5100.

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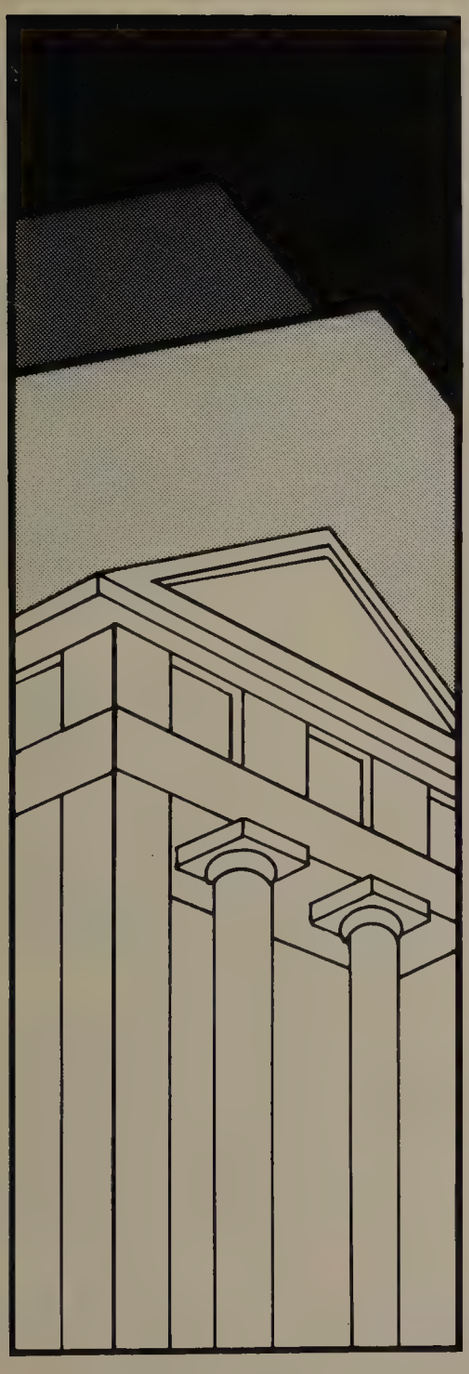

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Born to Talk?

by Peter Marler

The behaviorist B. F. Skinner viewed most human behavior as quintessentially cultural and structured by individual experience, with genetic factors playing a minimal role. His book on verbal behavior, published in 1957, struck a chord with a generation of like-minded anthropologists, linguists, philosophers, and psychologists. In the same year, Noam Chomsky's book on syntactic structures launched a direct confrontation with these behaviorists, arguing forcefully that we cannot begin to explain the complexities of language development without first recognizing the innate mechanisms unique to the human brain. Behaviorist dogma acknowledges that certain distinctive attributes of the human brain are required for the development of language, but these are thought to be merely the underpinnings for learning in general, with no direct bearing on the specific details of how language develops. A corollary of this empiricist view of language development, popular in the seventies and eighties, has been that concepts of innateness were not only scientifically questionable but perhaps even intellectually dangerous.

PATTERNS IN THE MIND: LANGUAGE AND HUMAN NATURE, by Ray Jackendoff. *Basic Books, Inc., $25; 246 pp., illus.* THE LANGUAGE INSTINCT: HOW THE MIND CREATES LANGUAGE, by Steven Pinker; *William Morrow and Co., Inc., $23; 494 pp.*

We have had to wait until the nineties for a more balanced view of the mechanisms underlying behavioral development. This new, more integrative position, appropriate for the era of the Human Genome Project, is well expressed in two creative and thought-provoking books, one by Chomsky's ex-student Ray Jackendoff and the other by Steven Pinker, a faculty colleague of Chomsky's at M.I.T. Both authors believe that genes play a much more dominant role in the development of human behavior than the behavioristic generation would have thought possible.

Jackendoff's *Patterns in the Mind: Language and Human Nature* and Pinker's *The Language Instinct: How the Mind Creates Language* accomplish more than a simple restatement and clarification of Chomskyan concepts, and their writings are most exciting when departing from the party line. Their approach is an exemplary illustration of how behavioral scientists can come to grips with the complex nature–nurture dilemma.

Jackendoff's lean, precise prose, blessedly free of jargon, launches us into these thorny issues. In the best tradition of an introductory text, *Patterns in the Mind* begins with a deceptively simple statement of purpose, setting forth a series of basic premises and then exploring their implications in more and more detail. Almost without realizing it, the reader is drawn into increasingly profound and complex topics as the book progresses.

Expanding on the theme of innateness, Jackendoff takes us through the basic tenets of Chomskyan insight. To account for the human ability to speak and understand novel sentences, we have to ascribe to the speaker's mind an innate mental grammar that specifies possible sentence patterns. That this specialized brain machinery drives a child to develop language is nowhere more forcefully manifest than in the signing behavior of the congenitally deaf. Deaf children deprived of access to a fully competent signing tutor often create their own private, so-called home-signing systems and invent some of the organizational features characteristic of spoken language. The parallels between speech and signing extend to the underlying brain mechanism. Studies of sign-language aphasias reveal that damage in Broca's and Wernicke's areas of the brain has the same effects on the comprehension or performance of signing that it does in speech, even though sign-language aphasics can use their hands perfectly well for other purposes.

Another compelling parallel between speech and signing (which also applies to the acquisition of a second spoken language) concerns sensitive periods of development when children learn most rapidly. Children who have acquired language before the age of seven achieve the greatest perfection in accent and are the most sensitive to vocabulary nuances. Jackendoff believes that

> nurture is maximally effective in language learning only when the proper elements of nature are in place—when a normal child is exposed to language during the critical period. If, for whatever reason, the proper elements of nature aren't in place, far more extensive nurture still doesn't produce performance at anywhere near the same level.

He puts it nicely when he writes, "Nature places its own stamp on nurture," and he believes that this imprint can be seen in other human behavior such as musical

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composition, where he contributes his insights as a concert clarinetist and horn player.

Some of the most stimulating ideas in *Patterns in the Mind* concern how meanings are actually encoded and used in the brain as a basis for thought and action. A child's brain accomplishes the phenomenal task of learning, on average, about ten words every day between the ages of two and five. That such a mind-boggling task could be achieved through learning by rote seems virtually inconceivable. Jackendoff argues, however, that if we think of the mind as full of elaborate machinery, actively and vigorously constructing concepts and associating those concepts with words, we can more easily grasp how such feats can be accomplished.

Pinker, in *The Language Instinct,* covers much of the same ground as Jackendoff, but more fully and in a different style. While Jackendoff writes with the relative austerity appropriate for what is essentially an advanced textbook on cognitive science and language, Pinker is clearly in love with language. The preface begins with a clear statement of intent: "to show that there is a world of elegance and richness in quotidian speech that far outshines the local curiosities of etymologies, unusual words and fine points of usage."

At times he writes as if he is intoxicated with the richness and diversity of languages and their content. In making a point, he is just as likely to quote from "All My Children" as from the Bard. Because the book is laced throughout with wit and humor, we might think that the entertainment is bought at the price of sacrificing scientific precision. But Pinker has a rare ability to express profound, original reflections in a way that is frankly entertaining. As a consequence, the book is a delight to read, even though it is packed with new ideas, often on difficult and challenging topics.

Although he is a follower of Chomsky and clearly reveres his mentor's intellect and insights, Pinker, like Jackendoff, departs radically from him in many respects. He points out that not all species universals—that is, attributes shared by all members of a species—are necessarily innate. He embraces a Darwinian approach to the evolution of language with an enthusiasm that one searches for in vain in the writings of Chomsky, who sometimes seems so bemused by the marvelous intricacies of language that he cannot imagine what the evolutionary antecedents might have been. Many of Pinker's insights are a direct consequence of his much broader approach to the biology of language. Pinker does not hesitate to criticize Chomsky's arcane style, whose technical analyses of word and sentence structure are often couched in "abstruse formalisms"—strict adherence to prescribed external forms. He characterizes Chomsky's discussions of flesh-and-blood speakers as "perfunctory and highly idealized." Perhaps as a reaction to Chomsky's predilection for formalisms, Pinker takes great pains to apply innateness arguments to language—with all of its colloquial blemishes and imperfections—as it is actually used. As a consequence, his case becomes all the more persuasive and compelling.

The emphasis in much of *The Language Instinct* is placed upon syntax, or the component of grammar that arranges words into phrases and sentences. Like Jackendoff, Pinker also believes that the creativity of the child's developing language only makes sense if an innate grammar exists (Chomsky's Universal Grammar). Much of the time, children's words, phrases, and sentences simply do not match anything they have actually heard. Some of the quirkiness of their speech makes sense if they are tenaciously adhering to rules that, in particular cases, may actually be inappropriate.

As compelling as the innateness argument is, it must not be overstated. At some organizational level, what children say must be determined by what they have heard. The underlying principles may be deeply hidden, but they are there and potentially available for the child to learn. These rules are often applied, even if (as happens so often in early speech) using them means violating some of the conventions of that particular language. Every parent can cite an example: "My teacher holded the baby rabbits and we patted them" or "I love cut-upped egg."

Neither Jackendoff nor Pinker will rule out the possibility that language is directly affected by an individual's genetic makeup. Linguist Myrna Gopnik studied a British family with thirty members, spanning three generations, that had a history of a particular grammatical speech defect that hinted strongly at a genetically based impairment. Once we have the idea that neuroanatomical abnormalities may be linked to linguistic behavior, postulating a genetic basis seems reasonable.

The many strange ways in which language can be disturbed by lesions resulting from stroke and other forms of brain injury (especially those involving Broca's and Wernicke's areas) are explored by both Jackendoff and Pinker. Pinker even develops a neural network model that would decode syntax. We have only to listen in on the lamentations of engineers trying to get their computers to process speech to appreciate the effortless ease with which the ears and brain of a baby accomplish the same task. Rarely do engineers seek inspiration from our understanding of how the brain does the job—or at least how we think it does it. Pinker presents his model, based on toy neurons, as a fun diversion, but he shows that, in principle, plausible networks can indeed be created. To determine whether they exist in the brain—and how the circuits are actually put together—is a daunting challenge for the next generation of neurobiologists. Pinker seems optimistic that they will be successful, perhaps soon.

Jackendoff, on the other hand, is more pessimistic. He gives what is, perhaps, a more realistic appraisal of the enormous gap between glimpsing a few aspects of how the linguistic machinery works (based on the observed effects of brain damage) and really understanding the microcircuitry that is responsible for normal function. Research at this level, although the subject of much theory, is a special art, only slowly being perfected by neurobiologists. Current targets are simple invertebrates, especially systems with small numbers of individually identified neurons whose physiological properties and interactions can be studied in great detail.

Direct investigation of the circuitry underlying language at this level of analysis in humans is not possible at present, but scientists thrive on such challenges. The battle is half won when researchers are convinced in principle that they have a meaningful set of hypotheses and models amenable to analysis at the cellular level. That is where we stand now in the study of the biology of language. The next step is up to the coming generation. Jackendoff and Pinker offer many pointers as to the direction that this research might profitably take.

Peter Marler, a professor in the Department of Neurobiology, Physiology, and Behavior at the University of California at Davis, specializes in animal behavior and is particularly interested in understanding how song dialects develop in birds. The author and editor of numerous papers and books about animal communication, Marler coauthored, with William J. Hamilton III, Mechanisms of Animal Behavior.

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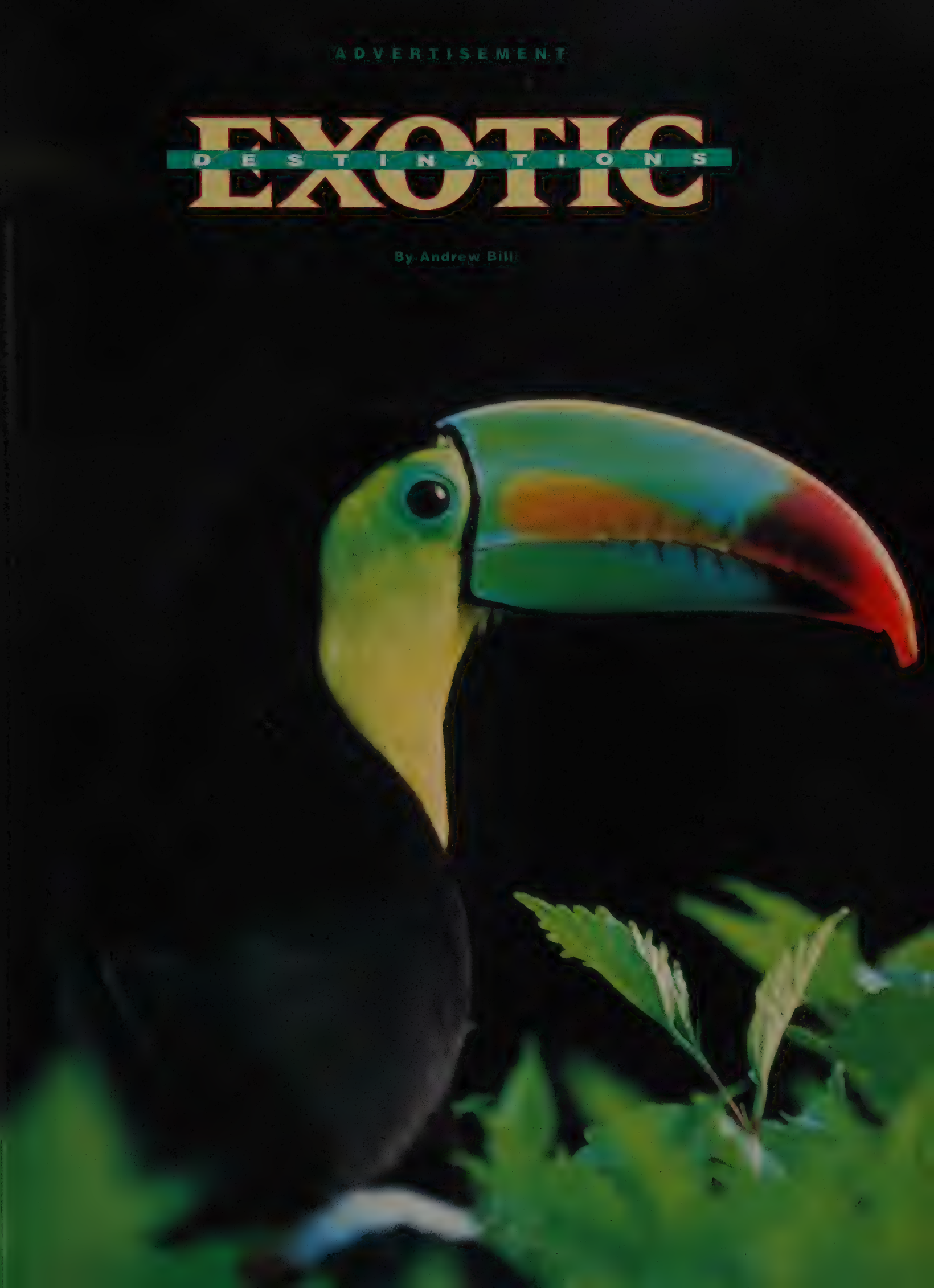
EXOTIC DESTINATIONS

By Andrew Bill



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Australia

Kakadu National Park

Ask any Australian naturalist which of that country's many parks captures most its incredible biodiversity and indigenous culture. He or she will no doubt talk of Kakadu, just east of Darwin on Australia's northern coast, which has been singled out by UNESCO as a World Heritage Site. Within its boundaries are woodlands, coastal fringes, wetlands, arid plateaus and southern hills — all in constant flux with the extreme seasons. These habitats are home to many of Australia's strange menagerie from dugongs (sea cows) and turtles on the beaches to crocodiles in the rivers, and goannas and kangaroos on land. Magpie geese, wandering whistle ducks, and ibises fleck the billabongs. Complementing this natural diversity, and an integral part of it, are the Aboriginal people who continue an unchanging lifestyle that they are happy to share with the modern visitor.

A careful study of pristine nature and accessibility, Kakadu has commercial tours ranging from the one day "rush-around" to a 15-day camp-out led by Aboriginal guides. Four-wheel drives are recommended for private parties. There are four eco-attuned resorts and lodges offering the highest level of comfort . Most visitors prefer the cooler temperatures of the dry season, May to September. For more information call (310) 645-9875.

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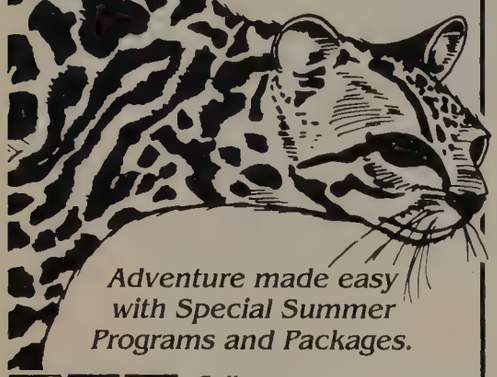

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Only increased to its present area of 100,000 acres in 1990, Cockscomb is ringed on three sides by high mountain ridges falling down to either side of the country's highest point, Victoria Peak. Within this dramatic amphitheater lives a remarkable concentration of fauna, most notably five species of feline — jaguar, puma, ocelot, jaguarundi, and, smallest of the lot, the diminutive margay — that prowl the forest by night in search of peccaries, Brocket deer, anteaters and tapir. Scattered through the canopy are more than 290 species of birds, ranging from the gaudy scarlet macaw and keel-billed toucan to the imposing king vulture. Armed with a comprehensive booklet, visitors can take self-guided walks along the forest paths, threading through the shadows of giant ferns and mighty mahogany trees, or may arrange for a tour by a member of the park personnel.

The sanctuary headquarters is located on a six-mile entrance road that leads from the village of Maya Center, which, in turn, can be reached by driving south from Belize City along the scenic Hummingbird Highway. The dry season runs from February through May. June to October is the wettest period. For more information, call (212) 563-6011.

Rufus-tailed hummingbird, Belize

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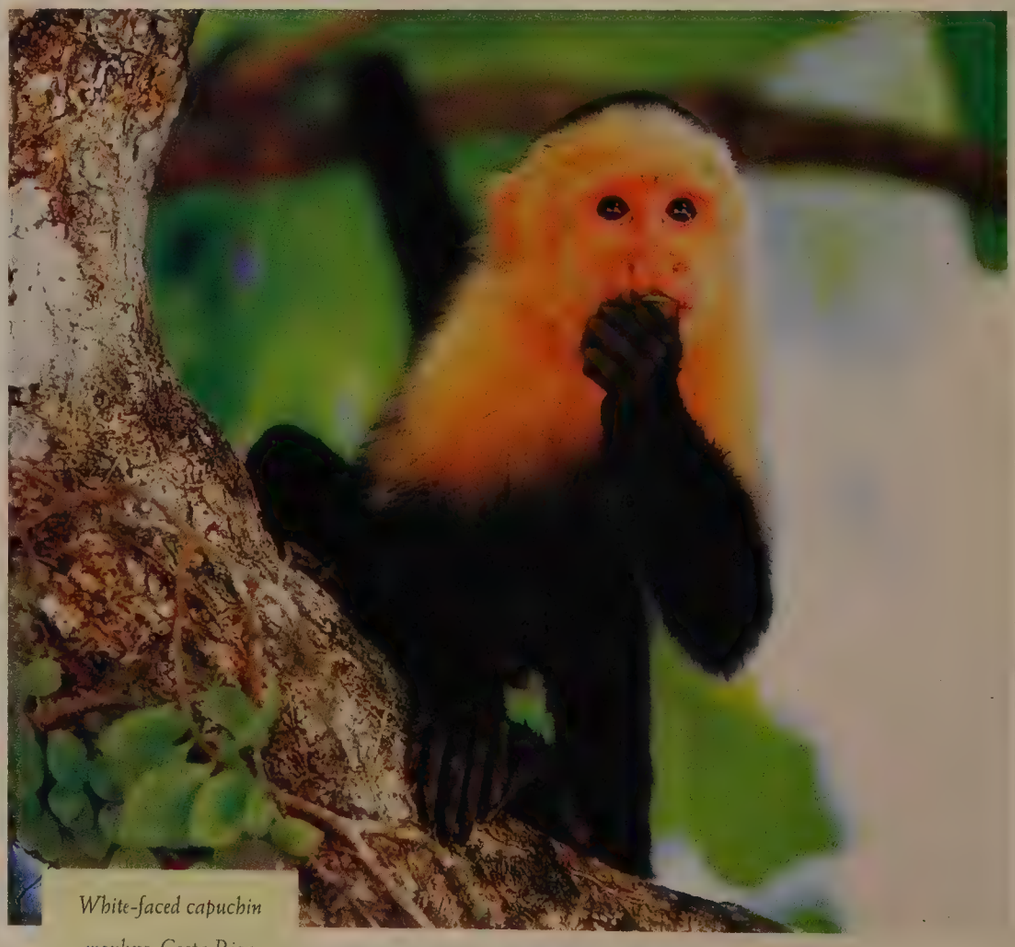

White-faced capuchin monkey, Costa Rica

TOM ULRICH, TONY STONE WORLDWIDE

Costa Rica

Corcovado National Park

Partly because 25 percent of the country is made up of wildlife refuges, and partly because of its incredible natural biodiversity, Costa Rica presents the naturalist with enormous choice. If forced to select one of its 20 national parks, try Corcovado, over 40,000 hectares of swamps and rainforest on the Osa Peninsula on the country's southern Pacific coast.

The broad range of habitats has spawned more than 140 species of mammals, from tapirs and crocodiles in the wetlands to silky anteaters, ocelots, and cougars in the low-altitude-cloud forests. As you walk the clearly-defined paths, crabwood and silk cotton trees suddenly shake as a family of capuchin monkeys with the faces of old men stops to stare down at the visitors. In quiet industry on the forest floor, leaf-cutter ants (just one of 6,000 insect species) march in endless and imperturbable columns. Looking skyward, bright scarlet macaws and the majestic wingspan of the great harpy eagle slash across the blue roofs of the clearings.

Despite its natural tranquillity, Corcovado is easy to reach by four-wheel drive vehicles cruise ship or light plane from Puerto Jimenez. Accommodations run the gamut, starting at the resort level — Albergue Lapa Rios (near Puerto Jimenez), Villas Rio Mar (Dominical). The season runs all year with light rains May to November. For more information: (800) 327-7033.

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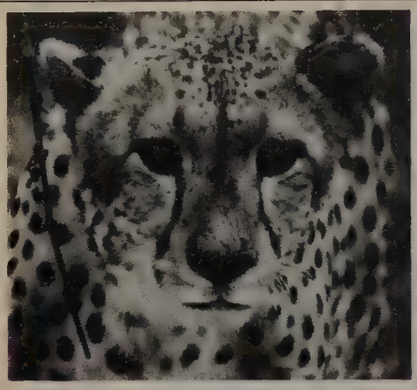

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A baby Indian elephant feeds on hay

Other notable wildlife includes leopards, wild elephants, and sloths.

Just 230 miles from the major gateway of Delhi, Corbett is easy to reach by car. Visitors should stop in the town of Ramnagar (the entrance to the park) to arrange tours and accommodation in the Dhikala area of the park, where tented camps and forest rest houses can hold up to 150 people. Corbett is only open November to mid-May. For more about India's national parks, call the tourist offices at (212) 586-4901 (east coast) or (213) 380-8855 (west coast).

New Zealand

Kahurangi National Park

It's a mark of New Zealand's commitment to conservation that a country already known for its wide open expanses, low population, and pristine environment also has 38 parks. These mirror the country's diverse terrains from rain forest in the north to glaciers in the south.

New Zealand's newest addition to the list is Kahurangi National Park, opened in April of this year and located in the north-west corner of the South Island near the already celebrated Abel Tasman and Nelson Lakes national parks. Kahurangi is the nation's second largest (next to Fiordland) and, complementing the country's acclaimed flora and fauna, contains many natural attractions found nowhere else in the country. Visitors can hike from coastal terrain to high country following the Heaphy and Wangapeka walking tracks, enjoying more than half of the country's 2,270 plant species. Ornithologists can take this rare opportunity to find endangered species like the great spotted kiwi, blue duck, falcon and rock wren. Spelunkers can explore the country's longest cave system (22 miles) and deepest cave.

Paved roads from the Picton ferry connect the North and South islands, or visitors can take domestic airline flights to Nelson. Organized hiking tours complete with guide are available. Accommodations within the park are at designated camp sites. Rustic inns and deluxe hotels pepper neighboring towns. For more information call the tourist office at (310) 395-7480.

Panama

Soberania National Park

Soberania is one of the most accessible parks in Panama and one of the few places where you are guaranteed sightings of the larger fauna.

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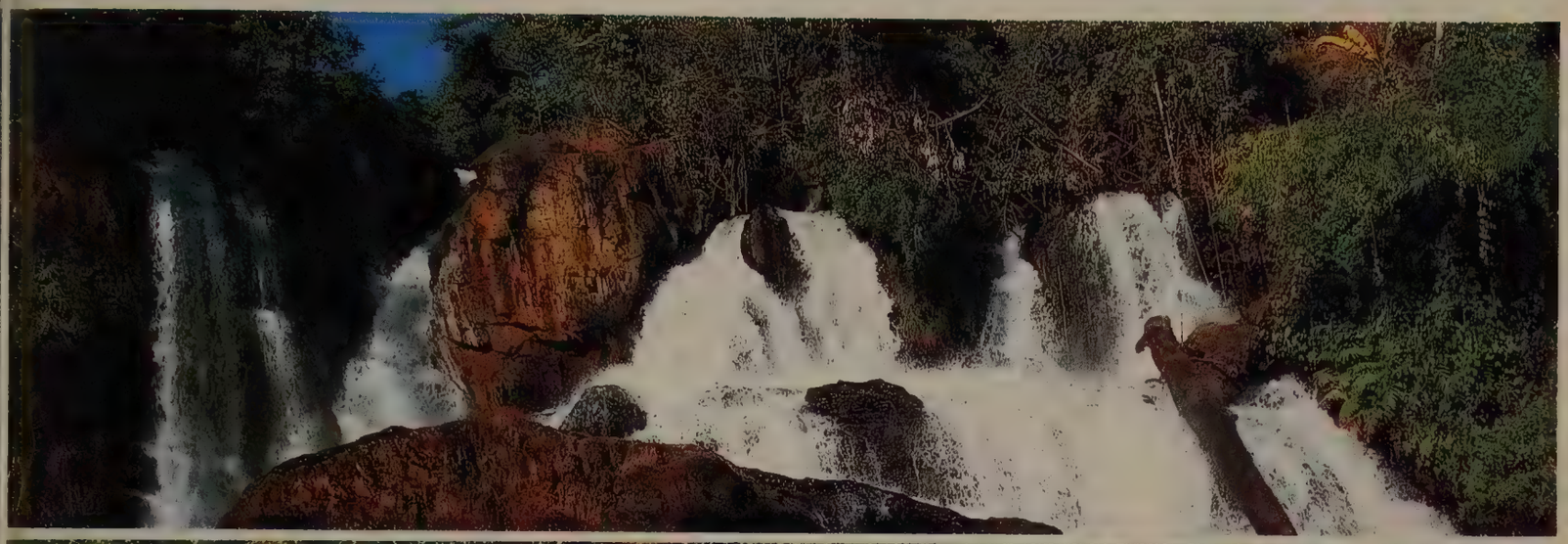

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park ends, refreshingly, at the lush Agua Salud waterfall that flows into Lago Gatún. Another trail in the south, the Sandero el Charco, has the major flora clearly marked. Forest ranger guides are well-informed about forest lore. The Summit Botanical Garden and Zoo affords glimpses of those otherwise-elusive capuchin and howler monkeys, jaguars, and parrots.

To get to the park from Panama City, just drive northwest for 30 minutes to the town of Gamboa. Most visitors opt for the dry season, November to April, although the rainy season also has its merits. For more information call (800) 726-2627.

Puerto Rico

El Yunque National Forest

Remarkable in an island only 110 by 35 miles, Puerto Rico has over 20 designated forest reserves scattered across rolling hills, desert and rain forest. The finest example, both for its size, and long history, is El Yunque, an easy 45-minute drive east from the capital of San Juan.

Its 28,000 rain forest acres cater to both the day-trip picnicker and the serious naturalist. For the latter, 13 trails lead off through four distinct forest types from rain forest to dwarf cloud forest, made up of over 240 species of tropical trees, 20 species of orchids, 50 varieties of ferns. As you walk through the shadows, you become aware of the forest's contradiction — silence and din — as thousands of tree frogs chirp "coqui," and birds, including the magnificent Puerto Rican parrot, call forward and back. At least 26 mammal species — such as the Puerto Rican boa — are unique to the island. One of the most rigorous trails winds up 3,523 feet to the top of the Pico El Toro, while Big Tree Trail, an easier alternative, ends at La Mina Falls. A tropical forest center, for better appreciation and study of the rain forest, is currently under construction.

If, after the hike, you want a more relaxing afternoon, bring a picnic and take the short drive down to one of the island's most spectacular beaches, palm-fringed Luquillo. Most hotels and resorts offer day trips. For more information call (800) 223-6530.

El Yunque rain forest

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South Africa

Hluhluwe Game Reserve

All of South Africa's 17 national parks offer a variation on the big game experience. The best known is Kruger, with its many rest camps and large staff. One of the oldest of these reserves is Hluhluwe (pronounced shush-lui), located in Northern Zululand (north of Durban) and frequently linked with its sister reserve of Umfolozi. Here, amid a rare combination of forest, grasslands, and woodland savanna, visitors can expect to sight the oddly-graceful giraffe

feeding on uppermost branches, cheetahs lazing in the sun, or hear the distant laughter of hyena. Crocs and hippos wallow in the rivers. This is the only park in Natal where you will see Africa's "big five" — elephant, lion, rhino, leopard and buffalo. An even rarer opportunity is to see the white rhino, once reduced to only 50 head but pulled from the brink of extinction in the early 60s. After driving the self-guided auto trails or taking a hike, guided by a game guard, across the varied terrain, visitors can head back to the comfort of the newly-renovated Hilltop Camp for cocktails and sunsets.

The best approach to Hluhluwe is by car either from Johannesburg (5 hours) or from Durban (3 hours). Otherwise special interest groups offer tailored tours. From May to August the shorter grass makes it easier to spot the game. Later, in the dry season, the game collects around the water holes. For information call (800) 822-5368 (eastern U.S.) or (800)-782 9772.

Thailand

Huai Kha Khaeng Wildlife Sanctuary

Huai Kha Khaeng was made a wildlife sanctuary in 1972, and its virgin forests, praries, and streams became a U.N. World Heritage Site two years ago. Huai Kha Khaeng presents the serious naturalist with a superb opportunity to explore natural attractions that have disappeared in other parts of Southeast Asia. Larger mammals include the elephant, tiger, leopard and tapir. The sanctuary's lowland deciduous forests — mostly of Indo-Chinese origin — are home to 10 primate species including the rare Phayre's leaf monkey and the Rhesus macaque. The lower branches are the playground of flying lemurs and their cousins the flying fox, while the tree-tops are bright with 415 species of birds, including the wreathed and great hornbills, green peafowl and yellow-footed pigeons. On the slopes of Tanawasee Mountain, you might hear Fea's barking deer.

Huai Kha Khaeng is not open to everybody. To arrange a visit, permission must be sought from the Conservation Division of the Forestry Department, the governing body that will also advise on accommodations and private guides. Call Bangkok (02) 579-4842.

United States

Glacier Bay National Park

Few national parks can compare with the sheer majesty and size of Glacier Bay. Outstanding even in a state with 15 national park areas, it encompasses 3.3 million acres of raw nature, untamed and untouched.

Most people experience its drama from the sea (see "Smooth Sailing"). At this level the two major attractions are the tidewater glaciers that abut the sea in blue ice walls that move with the slowness of millennia

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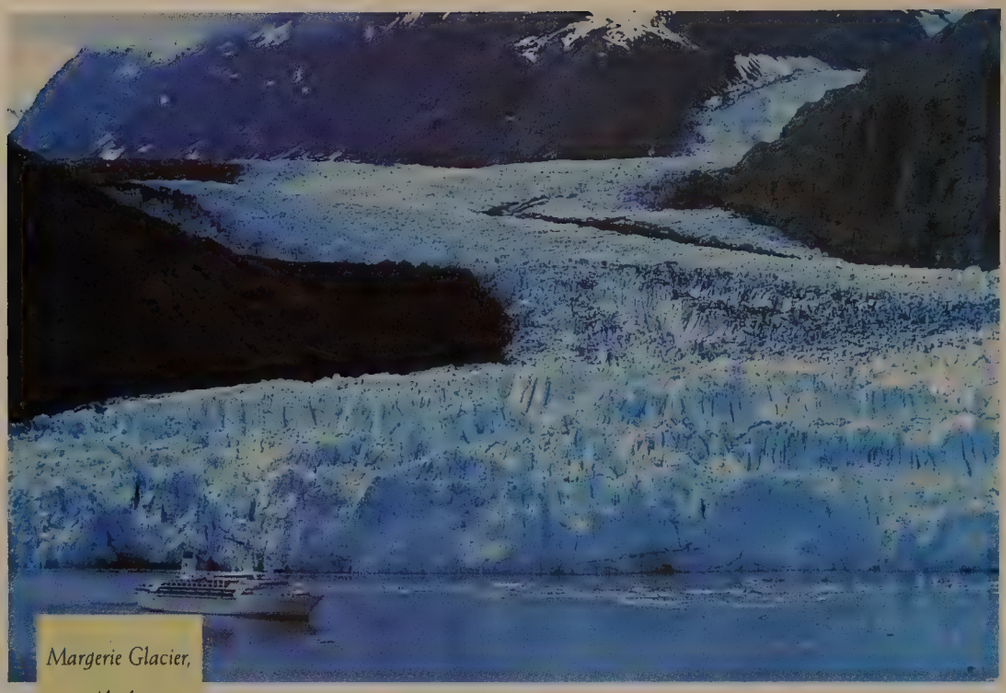

COURTESY GLACIER BAY NATIONAL PARK

Margerie Glacier, Alaska

(occasionally releasing house-size chunks with a crack like a pistol shot) and the sea life from black and white guillemots to whales. Schools of orcas and humpbacks glide by oblivious of passing ships. But the park also extends beyond the coast rising from barren terrain left behind by retreating glaciers to the dank deep-greens of temperate rain forest. Its Mount Fairweather is the highest peak in southeastern Alaska. Those hiking its back country will come across many of North America's great land mammals including brown and black bears, mountain goats and moose.

There are no roads into the park. The easiest access is by scheduled boat and air service from Juneau, 65 miles away. Hikers planning in-land trips must arrange to be dropped by tour boat or float plane and should attend one of the twice-daily orientation talks at the park lodge (55 rooms) at Bartlett Cove. Guided hikes, kayak and rafting trips are also available. For more information call (907) 697-2230.

Andrew Bill is a free-lance journalist based in New York and specializing in travel and design.

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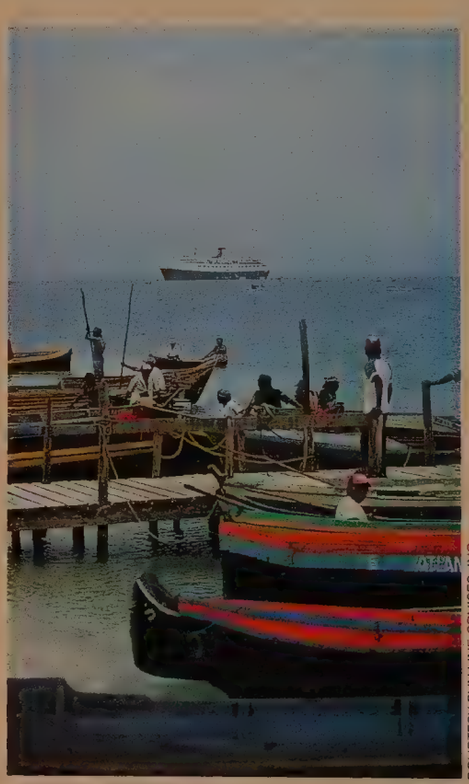

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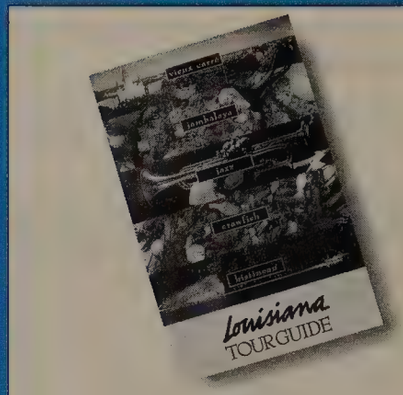

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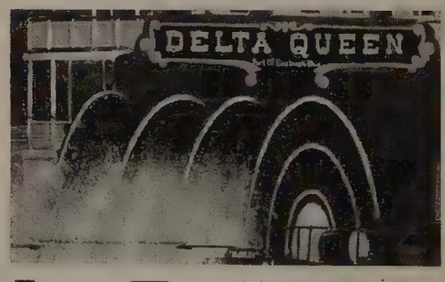

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A View Outside the Galaxy

by Gail S. Cleere

A quick look at a star map for early evening in October shows that one of the least interesting areas of the celestial sphere has now spread itself before us to the south. As always, the northern sky is occupied by Polaris and the Big Dipper, which circles the North Star throughout the year; but in the southern half of the sky, things have changed. The dense swath of the Milky Way that stretches across the sky on summer nights, has now sunk below the western horizon, and the glittering jewels of our winter sky have yet to rise in the east. In the hours after sunset, only a single first-magnitude star presents itself to us: Fomalhaut (which in Arabic means "mouth of the fish").

There is a reason for this dearth of bright stars in the autumn sky. On summer evenings, when we look toward the bright stars of Scorpio and Sagittarius to the south, we face the center of the Milky Way, with its concentration of stars obscured by a band of dark, interstellar dust. In October, however, when we look south past Piscis Austrinus (the Southern Fish) and Fomalhaut, we are facing the emptiness of intergalactic space.

Although Fomalhaut is almost twice the diameter of our sun and fourteen times more luminous—at a distance of twenty-three light-years, it is only the eighteenth brightest star in the sky. Because it is located in an area of the sky that is so sparsely populated by bright stars, it is sometimes called the Solitary One. Fomalhaut is surrounded by the faint stars of the water constellations: Aquarius (this month home to the planet Saturn), Delphinus, Pisces, Cetus, and Eridanus.

By midnight, however, our familiar winter friends—Taurus, Orion, Gemini, Canis Major—lumber up over the eastern horizon, recognizable, reassuring, and comforting. By midnight, Fomalhaut is nearly gone, and by midmonth it has set below the western horizon. By November, the winter Milky Way will rise over the eastern horizon, and our attention will be drawn toward the dense stars of the spiral arm of the galaxy that we live in.

THE PLANETS IN OCTOBER

Mercury is visible early in the month in the evening sky, but then passes between the earth and the sun, reaching inferior conjunction on October 21. By the end of the month, Mercury is again far enough away from the sun to be seen, and its best morning sky apparition of 1994 begins.

Venus is low in the southwest at sundown, disappearing on the western horizon by midmonth. If your southwestern horizon is very clear on the evenings of the 6th and 7th, look for the pretty grouping of Venus, Mercury, Jupiter, and the thin crescent moon just after sunset.

Mars rises just past midnight, well after the bright stars in Orion have led the charge across the October skies. At the beginning of the month, look for the red planet between the star Procyon, in Canis Minor, and Gemini's Castor and Pollux. On the morning of the 28th, Mars is 7° above the waning crescent moon.

Jupiter is low in the southwest at sunset, succumbing quickly to the solar glare. It remains in the constellation Libra.

Saturn is in the faint constellation Aquarius, well up in the southeast as the sun goes down, and does not set until after midnight. Enjoy it now, because next year this planet's magnificent rings will face us edge-on and will not be visible through telescopes. On the 14th and 15th, the waxing gibbous moon passes well north of Saturn.

Uranus and **Neptune** remain together in Sagittarius, following the summertime constellations as they dip below the western horizon in early evening.

Pluto and the giant planet Jupiter share the constellation Libra this month.

The **Moon** is new at 11:55 P.M., EDT,

n the 4th; first-quarter moon is at 3:17 P.M., EDT, on the 11th. The full moon, at 8:18 A.M., EDT, on the 19th, is called the hunter's moon. The moon reaches last quarter on the 27th at 12:44 P.M., EDT.

The Orionid meteor shower occurs on the evening of October 21–22, when the earth glides through the orbital path of Halley's comet. You will be treated to an average of 25 "falling stars" per hour. Last seen in 1986 and due back in 2061, the comet left behind small pieces of itself, blown off from its nucleus as it made close approaches to the sun.

The Orionids will peak two hours after midnight on the 22d for those in the eastern time zone. These are, coincidentally, the best hours to observe the shower from any location because the leading edge of the earth is rotating directly into the orbital path of the shower itself. Unfortunately, the moon is up for most of the night and may obscure some of the show.

Remember that on the last Sunday of October, at 2:00 A.M., you are to set your clocks back by one hour if your locality adheres to daylight saving time. This will put you back on standard time.

Gail S. Cleere lives in Washington, D.C., and writes on popular astronomy.

ERRATUM: In "Moonstruck" ("Celestial Events," April 1994), the distance to the moon at its April 11 apogee was misstated as 252,574 miles; the earth and moon were actually about seven miles closer together. In Gail Cleere's original manuscript, the distance was correctly given as 406,468 kilometers. For the reader's convenience, *Natural History* converts from metrics to more familiar units of measure. Apparently, the conversion factor in one of our calculators was not expressed to the necessary number of digits for accuracy where very large numbers are concerned. Hence the seven-mile discrepancy in the distance to the moon.—*Ed.*

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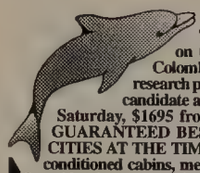

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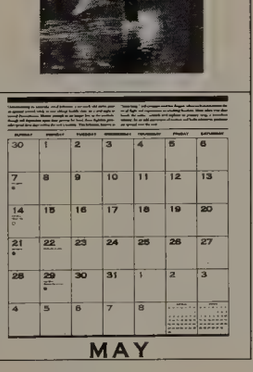

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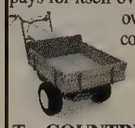

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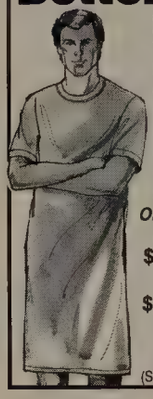

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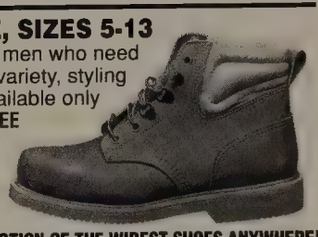

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Top Hat and Tails

Each winter, male white-tailed deer cast off their antlers completely and in spring must start a new set from scratch. Fed by a covering of living, blood-enriched "velvet," antlers grow rapidly throughout the summer. In early fall, the velvet is shed in bloody strips, revealing the beauty of the underlying bone. Only then is a buck ready for the rigors of the autumn rut—the hormone-fueled rites of intimidating his rivals and attracting mates.

Rutting whitetails often vigorously rub their heads against trees, and in the process may leave pungent, as well as visible, signs of their passage. This buck, photographed in early October in northern Minnesota's Tamarac National Wildlife Refuge, was thrashing around the forest edge when he began a battle with the low-hanging branches of a small maple. Then he indulged in a ritual seldom seen in whitetails. He made no effort to dislodge the leaves and limbs that clung to his antlers but carried them aloft as he strutted around the clearing. When this harvest eventually fell off, the buck again attacked the maple. He was last seen dissolving back into the woods wearing a cap of red-orange leaves at a rakish angle.

In whitetails, antlers serve not only as sparring weapons but also as identity badges and status symbols. According to Valerius Geist, of the University of Calgary, who has studied deer throughout the world, European red deer and the barasingha and rusa deer of Asia frequently resort to vegetative enhancement of this male attribute. At least one Minnesota whitetail is following such deer tradition, increasing its stature by behavior that Geist compares to putting on a hat.—*J. R.*

Photographs by Erwin and Peggy Bauer

Near the shore of Lost Lake in the Cascades, **Andrew R. Blaustein** (page 32) and Susan Walls, then a postdoctoral student, inspect toad eggs in experimental enclosures. Blaustein's study of amphibian population dynamics, which he has conducted for fifteen years, seems to have had its roots in his childhood. Although he grew up in New York City and Long Island, Blaustein remembers catching lots of toads and frogs while on family vacations in Maine and New Hampshire. His love of nature, reinforced by trips to the American Museum and a menagerie of exotic pets (which he still maintains), led him to study biology. After earning his B.A. from Southampton College in 1971, he headed west to pursue his master's degree at the University of Nevada at Reno and his Ph.D. in biology at the University of California at Santa Barbara. His thesis focused on the population dynamics of rodents, but after moving to Oregon State University in Corvallis, where he is a professor of zoology, Blaustein switched to amphibians because they were better for investigating the kinds of questions he wanted to answer. Now that he has established a link between the death of some amphibian eggs and increased UV-B radiation from the sun, Blaustein plans to continue studying how this and other factors might be contributing to the decline of many frogs, toads, and salamanders.

Ecologists **Michael Steele** and **Peter Smallwood** (page 40) first learned that they shared similar research interests in squirrels, oaks, and acorns nearly a decade ago, when they met at Highlands Biological Station in the southern Appalachian Mountains of North Carolina. But Smallwood, below right, was busy at night studying the foraging behavior of long-jawed spiders, while Steele, left, was gone during the day studying shrew and rodent community ecology. Collaboration had to wait until they met again in Pennsylvania, where they teach at separate colleges. (Steele is an assistant professor at Wilkes University, and Smallwood lectures at Bryn Mawr.) Steele's interest in natural history goes back to his early childhood, when he collected "butterflies, other insects, and a variety of reptiles and amphibians around Chesapeake Bay. Mammals were too hard to catch then." Smallwood, a self-defined "eclectic," is going beyond spiders and squirrels to investigate sex ratios in the Florida kestrel, or sparrow hawk. ("We've discovered that they raise primarily sons early in the breeding season, and primarily daughters later on. We're trying to understand why.") For further reading, the authors recommend *The Natural History of Squirrels,* by John Gurnell (New York: Facts on File, 1987), *Food Hoarding in Animals,* by Stephen Vander Wall (Chicago: University of Chicago Press, 1990), and *Faith in a Seed,* by Henry David Thoreau (Washington, D.C.: Island Press, 1993).

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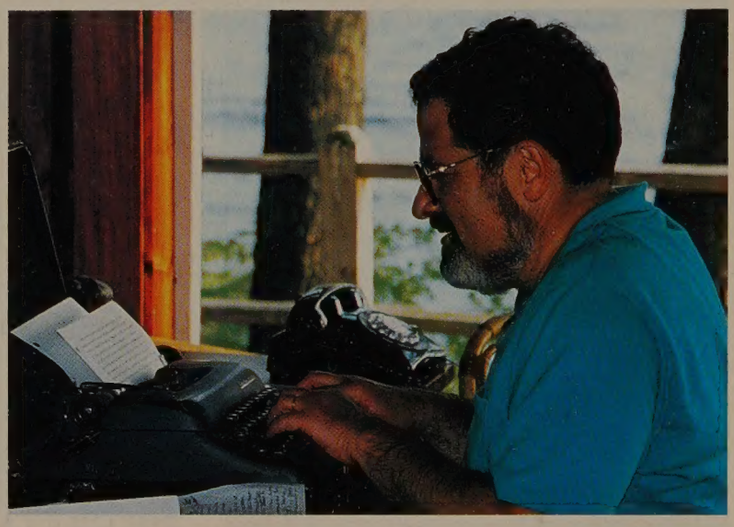
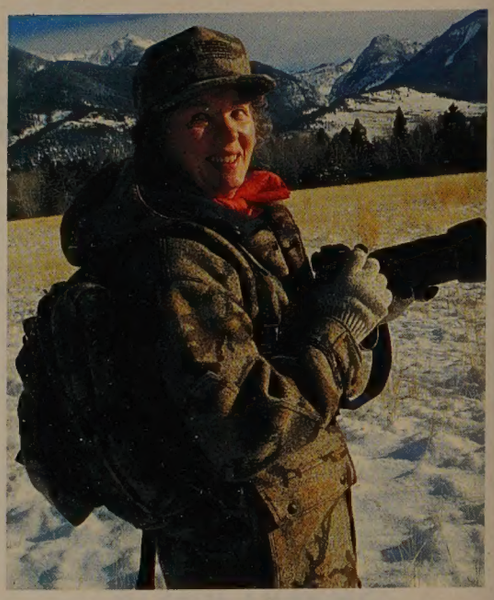
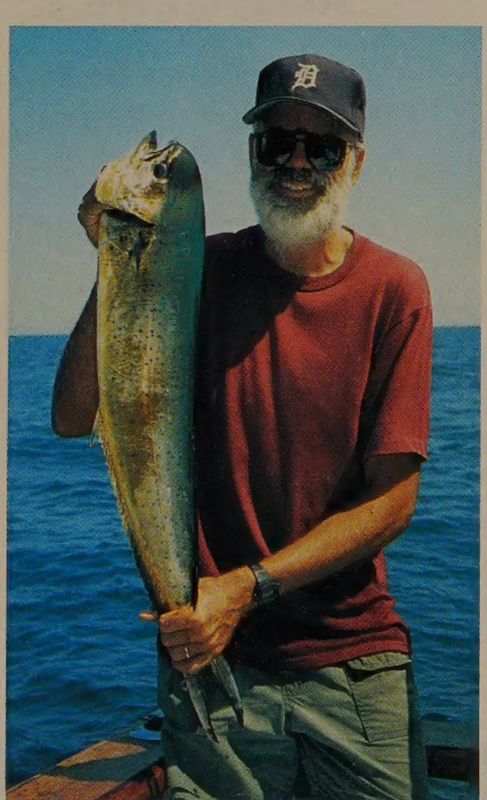
"I never laid eyes on a horse until my parents moved to Manhattan and I saw one in Central Park," says **Morris Rossabi** (page 48), who was born in Alexandria, Egypt, and lived there until the age of nine. "And my first glimpse of a yurt—in fact of any Mongol environment—was in a diorama at the American Museum of Natural History." Those early impressions captivated Rossabi, who earned his Ph.D. in Chinese and Inner Asian and Mongol history from Columbia University in 1970 and has taught and written on these subjects ever since. Formerly at Case Western Reserve University's China Institute, Rossabi is now a professor of Chinese and Inner Asian history at City University of New York (Queens College) and a visiting professor at Columbia University. The author of *Khubilai Khan* and *Voyager from Xanadu,* he is now halfway through a multivolume history of the Mongols and has almost finished a study of Roy Chapman Andrews's Mongolian expeditions. On frequent field trips, Rossabi has had many occasions to ride Mongol horses and to live in yurts. For more about these topics, Rossabi recommends *The Mongols,* by David Morgan (Oxford: Basil Blackwell, 1987), and *Genghis Khan,* by Paul Ratchnevsky (Oxford: Basil Blackwell, 1991).





Erwin and **Peggy Bauer** (page 88) make their home in Montana, but as full-time wildlife photographers, they have covered the globe. Truly a team, they are not certain which of them took the pictures of the white-tailed deer for this month's "Natural Moment." Erwin says, "We always shoot together and almost never know who did what." They photographed the white-tailed buck crowned with leaves using a Canon EOS1 camera and 600 mm lens. This month marks a record seventh time that the Bauers' work—from wart hogs to polar bears—has been featured as a "Natural Moment." The Bauers have numerous books to their credit. Their last was *Wild Dogs: The Wolves, Coyotes, and Foxes of North America,* published by Chronicle Books, and their next will be *Antlers,* to be published by Voyageur. More information on white-tailed deer can be found in *Whitetails* (San Francisco: Voyageur, 1993), with photos by Erwin and Peggy and text by Erwin. Whitetails are put in context with their relatives throughout the world in *The Natural History of Deer,* by Rory Putnam (Ithaca: Cornell University Press, 1989).

Theodore H. Fleming (page 58), his mathematician wife, Marcia, and their eighteen-year-old daughter, Cara, have traveled widely throughout Mexico for the past few seasons "chasing bats and cactuses." Fleming earned his doctorate in zoology from the University of Michigan in 1969 (for a thesis on tropical rodents) and is now a professor of biology at the University of Miami. He conducted several long studies of fruit bats in Central America (see *Natural History,* June 1985), and his interest in bats led him to investigate cardon cactuses, whose complicated sexual system he is still trying to unravel. Fleming is dismayed by recent changes in the cape area of Baja California and the coastal regions of Sonora, where developers are plowing under vast tracts of cardons to make way for new resorts, condominiums, and golf courses. "Cardons live in places that people now like to live in too," he says, "but it's a shame that this complex ecosystem, which we don't yet understand, is being disrupted." For further reading, Fleming recommends *The Cactus Primer,* by Arthur C. Gibson and Park S. Nobel (Cambridge: Harvard University Press, 1986), *The Evolution of Sex,* edited by Richard E. Michod and Bruce R. Levin (Sunderland: Sinauer, 1988), and Charles Darwin's *The Different Forms of Flowers on Plants of the Same Species* (Chicago: University of Chicago Press, 1986).



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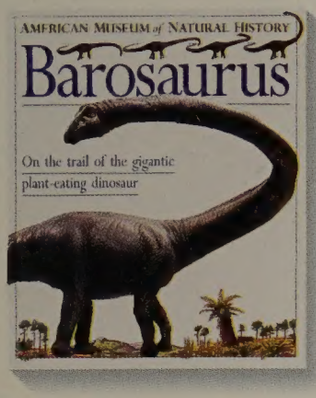

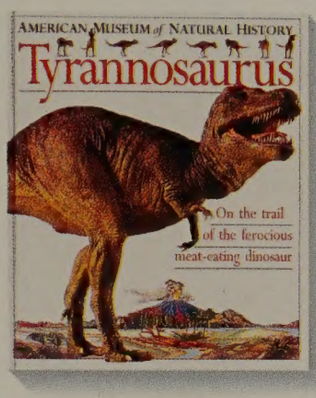

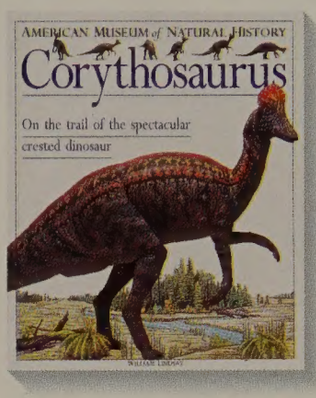

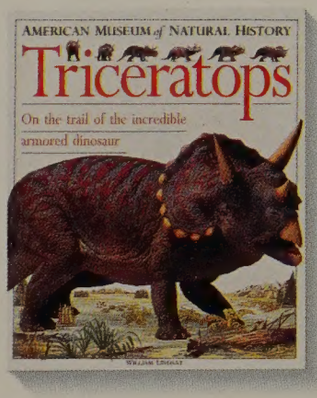

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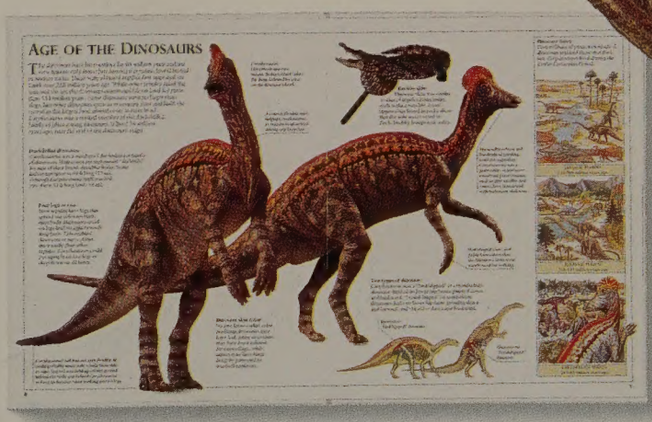

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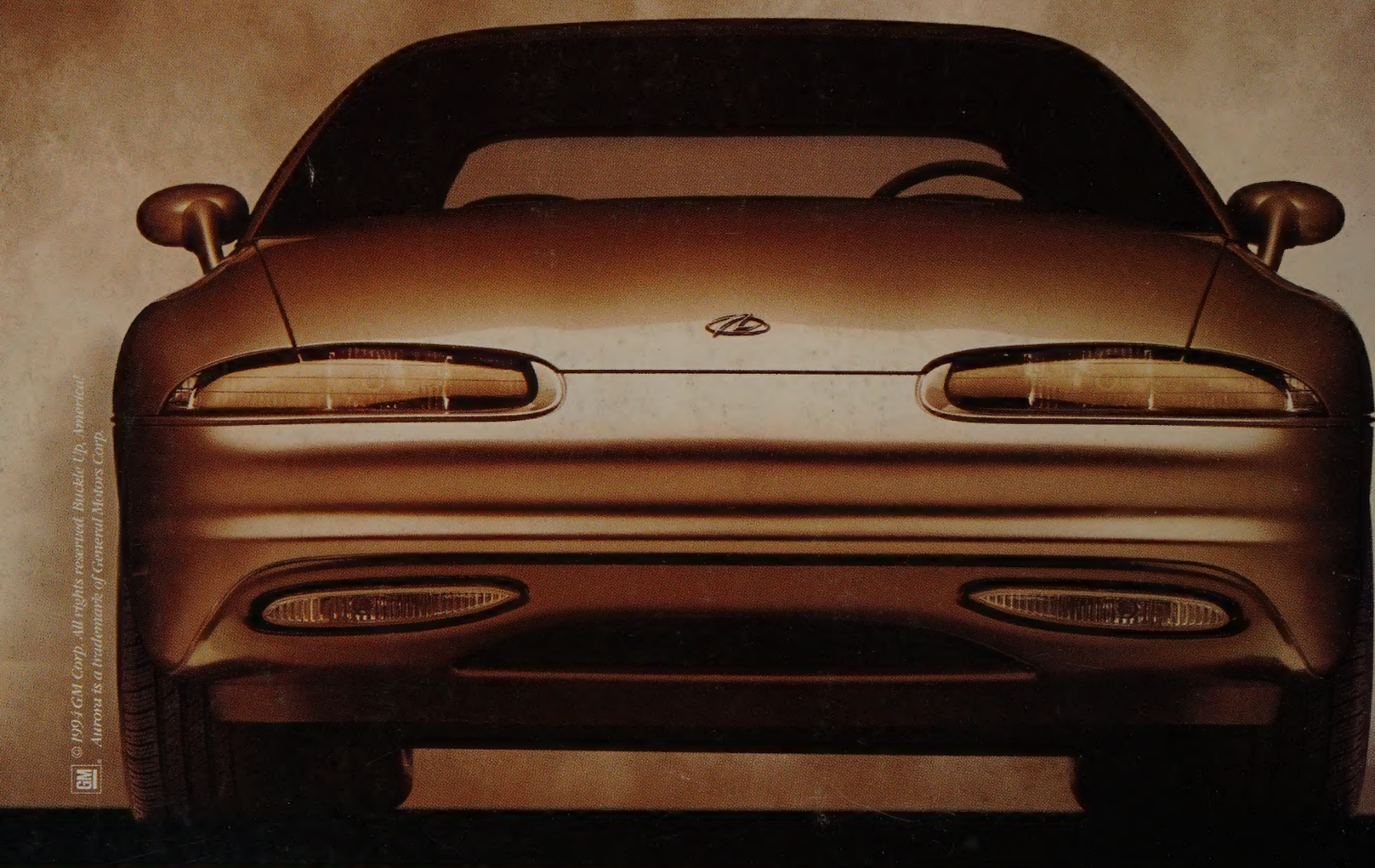

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